Comparative Cost-Benefit Analysis of Agriculture and Aquaculture in Fluvio-coastal Khejuri over South Bengal Basin, India

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Abstract - Historical Khejuri, the study area of this research is situated on the western arm of the Hooghly and north-eastern bank of River Rasulpur having the fluvio-coastal dignity on geomorphologic scale over South Bengal Basin. In fact, huge *shrimp culture* in illegal, unscientific, unplanned and haphazard way has been expanding dramatically capturing the productive agricultural lands and eco-significant wetlands over the last two decades. This study is mainly to investigate the comparative human and environmental costs for both agriculture and aquaculture of this coast-riverine environment. The survey cum research shows the serious environmental impacts; ecological imbalances and various socioeconomic costs. Shrimp and fish cultivations are undoubtedly economically beneficial for a selected group of people, but it has unenthusiastically affected the livelihoods of landless and marginal farmers mining environment and ecology. Hence, the study may be a modest endeavor made to assess the economic potentiality vis-à-vis ecological impacts of both lives earning ways in the region. *Profit budget analysis, labour weighted production analysis, cost-benefit analysis, productivity index analysis, LULC analysis*, etc. have been weighted as the significant methods with the extensive literature review, quantitative and qualitative survey for this study. Setting goals and scope to *sustainable aqua-development* and *integrated management* policy, this paper also tries to provide the blueprint for micro-level planning and development using *4-C framework, 4-R model and 4-M techniques* with respect to the red reality and conflict of two leading economies in study area.

Key words: ***profit budget analysis, productivity index analysis, cost-benefit analysis, sustainable aquaculture, integrated management, 4-C framework***

I. INTRODUCTION

Where the Ganga ends up her more than a 2,500 km long journey embraces Sagardwip with two outspread arms and then plunges into the sea, Khejuri stands on the western bank of the western arm of the Ganga, alias Bhagirathi, allies Hooghly [4]. Today's Khejuri emerged from 16th century's twin sister islands born of Bhagirathi silt, provides her people with various occupations in her rural society. However, changes in occupation throughout the time have been discerned with the touch of modern science and technology and thus new occupations have emerged. Out of all the occupations, shrimp cultivation meanwhile gets popularity in the coastal and interior parts of Khejuri and also achieves momentum here. In the recent years, fish and shrimp farming has come up as an emerging economy in a big way that provides livelihood to a considerable proportion of the local population and has become second largest contributor (after agriculture) to the local economy.

Shrimp farming has been grown in fabulous manner in Khejuri coastal blocks particularly during the last decade. More than 80% of the existing shrimp units have been developed between 2008 and 2016 along the bank of rivers, channels and canals.

Observation, investigation, survey and analysis reveal that considerable amount of productive and potential fluvio-coastal lands have been given to shrimp farms. Economic gain is the ambitious key to this but this change is exerting an impact on rural socio-economic lifestyle. Modern shrimp farming have socio-economic costs, besides it forms the ecological consequences. These costs also include loss of coastal vegetation and wetlands, destruction of natural habitats, abstraction or contamination and salinization of ground water, organic matter and nutrient pollution, chemicals, diseases, harvest of broad stock and wild post-larvae (PL), introduction of exotic species, abandonment and use of fish meal in feeds. Unfortunately, ponds are mostly situated on riverine fertile agricultural lands, as fish

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ponds need brackish water with good drainage conditions. During the last one decade, there has been 29% reduction in livestock population as most of the grazing fields have been taken away by fish farms. Haphazard establishment of the farms has caused the natural breeding grounds of indigenous fishes and aquatic lives to squeeze affecting their species diversity to decay.

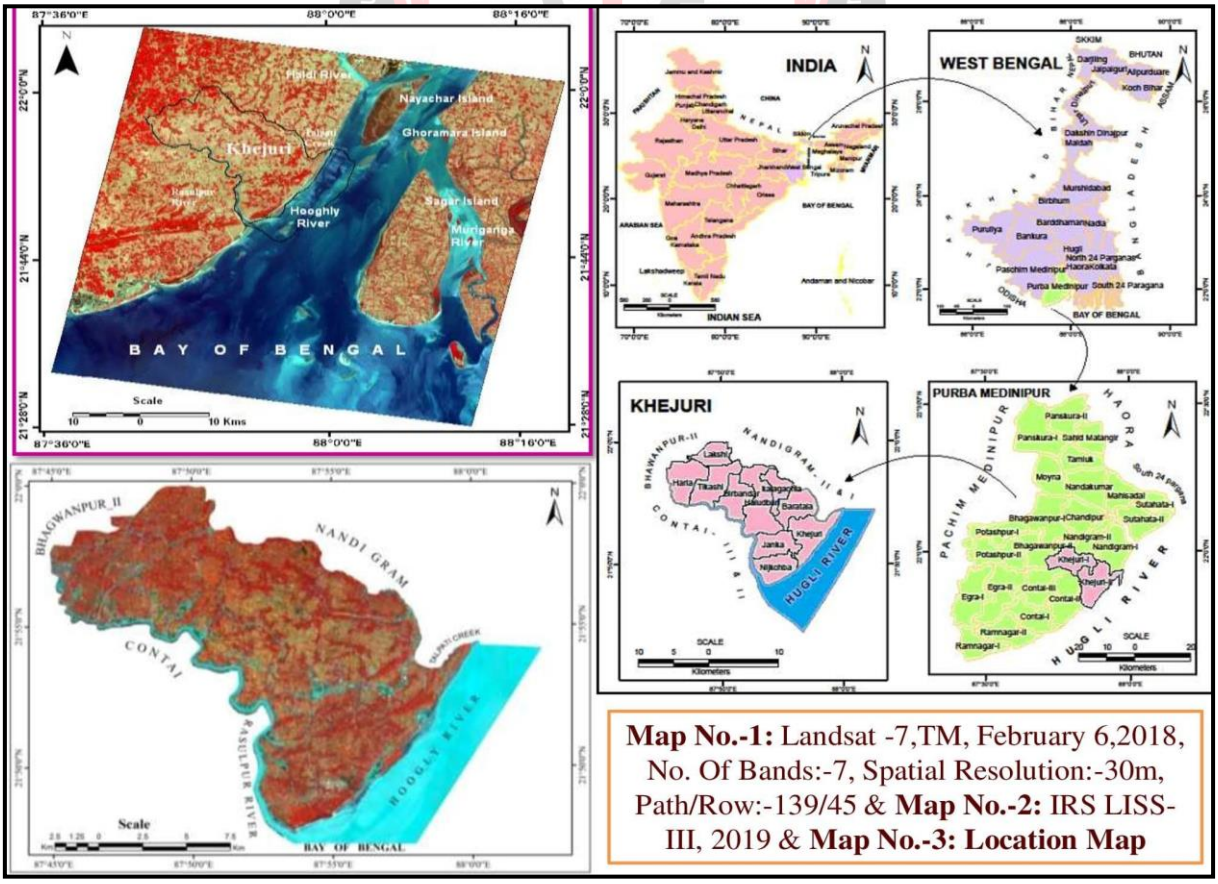
So, as with most development activities, including agriculture, here shrimp farming cum aquaculture is associated with a number of negative environmental impacts including habitat conversion; conversion of land from other valuable uses; nutrients and organic matter in effluent; chemicals used in soil, water, and disease treatment; salinization; and the introduction of non-native species or genetically distinct varieties.

The causes of environmental impacts are multiple, although rarely present all at once: poor planning and management of water supply and waste matter; deprived sitting; deprived design and technology; unfortunate management practices and lack of knowledge about latent environmental injure; high disease occurrence and connected exercise of chemicals; inadequate lawful frameworks and dictatorial instruments; fragile law enforcement; and the prospect of rapid, high earnings. The earning and turn over potential may undercut long-standing planning, development and far-sighted farm management, which can contribute to environmental protection if allowable to preside over decisions. Hence, there should be needed the scientific and technological studies to identify, quantify and assessing these problems precisely and drawing the managemental outline against those evils and implementing the micro-level planning as 'sustainable shrimp farming' in the study area.

In the comparison of two leading there is observed that short term socio-economic gain is higher in case of aquaculture whereas long term environmental and human costs draw its disadvantages with respect to agriculture. Under this backdrop, this paper attempts to such type of comparative study analyzing the cost-benefit perspectives. Here, lies the essence of this survey and research in terms of the hypothetical idea for measuring and managing the human and environmental costs of both life earning ways in the region.

II. LOCATION OF THE STUDY AREA

Khejuri is, geo-environmentally, one of the important coastal segments reflecting the typical coastal environment over Medinipur as well as West Bengal Coast. Geomorphologically, this region is situated over the 'geomorphic triple junction' of River Hoogly, River Rasulpur and Bay of Bengal, i. e., it shows the well convergence of closing journeys of River Rasulpur and Hooghly and happy beginning of Bay of Bengal. In fact, it has been featured by fluvio-coastal characteriscis in the combination of fluvial and coastal actions. Khejuri is existed on Rasulpur-Pichhaboni basin hydrology over Lower Ganga Course [3].



Map Plate-1: Location Map and Corresponding Satelite Images

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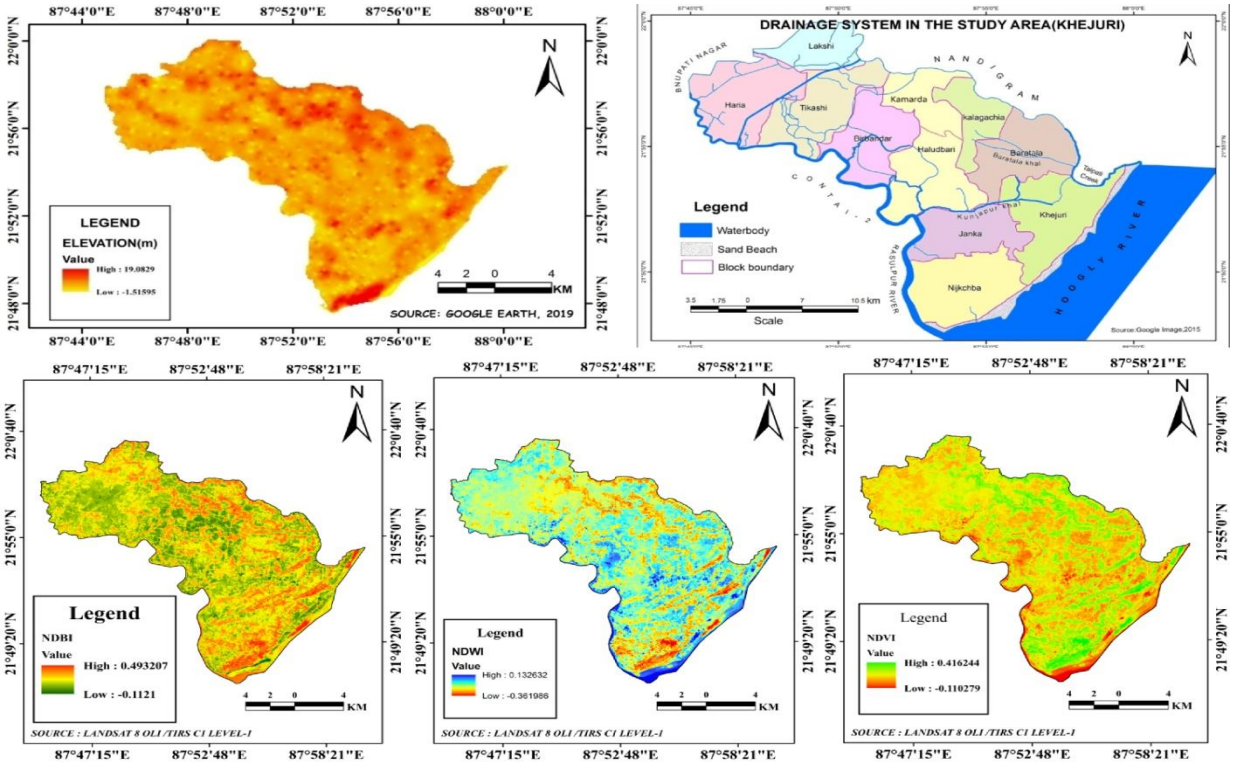
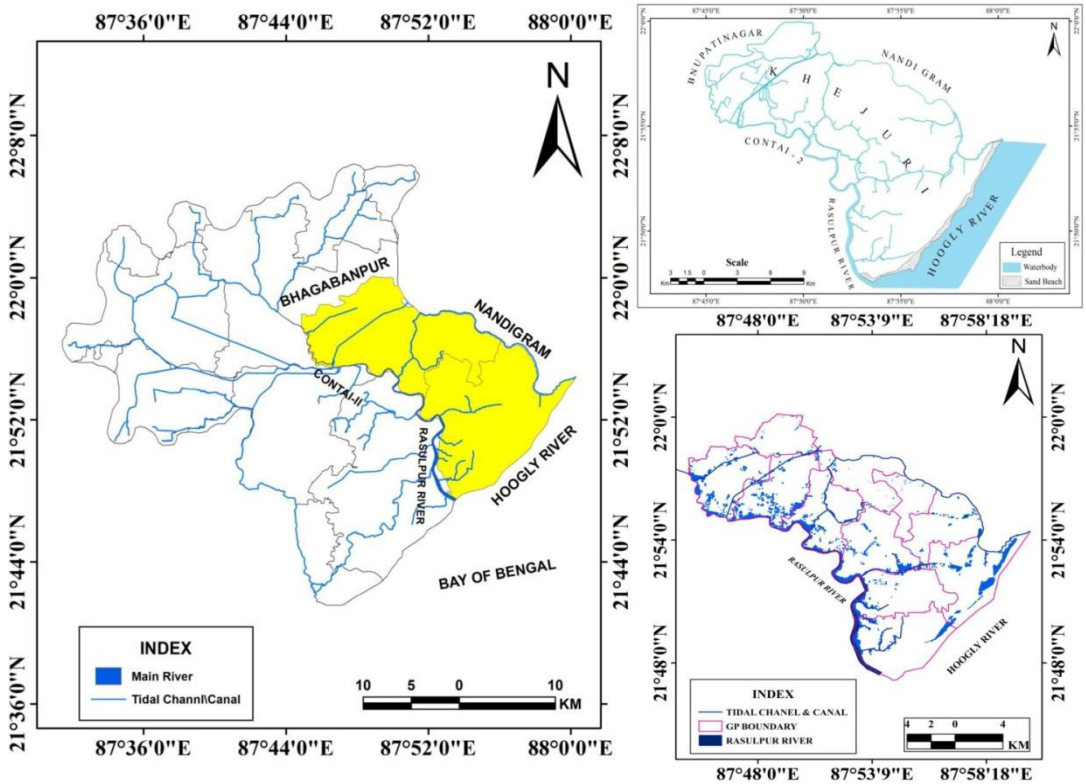
Geometrically this area is located in between 21°45´N - 22°00´N latitudes and 87°45´E - 88°05´E longitudes. So, it indicates the typical sub-tropical Monsoonal climatic location with its latitudinal and longitudinal entity over Indian sub-continent [3]. Geologically, it is of mostly recent formation which shows the sedimentary and lithological characteristics of recent Quarternery formation. Administratively, Khejuri is designated as one of the coastal police stations surrounded by Nandigram at the north, Bhagwanpur and Bhupatinagar at the north-west and west, Uttar Kanthi at the south (detouched by river Rasulpur) and River Hooghly and Bay of Bengal at the east and south-east [3]. Khejuri consists of two blocks as Khejuri-I and Khejuri-II and 11-Gram Panchayets (G.P.) named as Haria, Tikashi, Lakshi, Birbandar, Kamarda and Kalagachhia (6) in Khejuri-I CD Block and Baratala, Haludbari, Khejuri, Janka and Nij Kasaba (5) in Khejuri-II CD Block. From the democratic point of view, it is existed as Khejuri Assembly and included of Kanthi Constituency of Purba Medinipur district in West Bengal, India [3].



Map Plate-2: Maps relating DEM, Administrative Drainage, NDBI, NDWI and NDVI of the Study Area, 2019 & 2020



Map Plate-3: Drainage Network of Rasulpur Basin and Khejuri along with Its Drainage influenced Shrimp Culture

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III. OBJECTIVES

- To enlighten the illegal, undesigned, unplanned & haphazard growth and expansion of shrimp cultivation drawing the changing scenario of LULC in Khejuri
- To analyze the human costs of both aquaculture and agriculture comparatively in the study area
- To examine the environmental and ecological cost of both aquaculture and agriculture comparatively in Khejuri
- To make the outline with possible plan, policy and strategy for 'Blue-Green Sustainable Development' and "Integrated Management" of two leading economies in the potential fluvio-coastal Khejuri

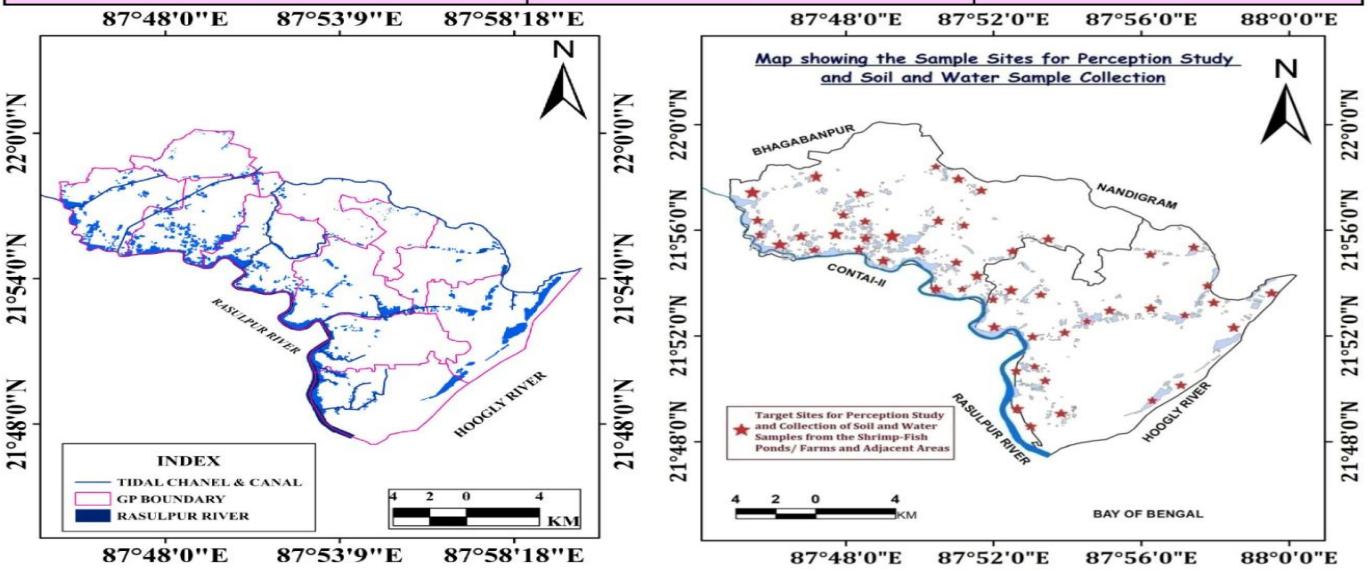
IV. METHODS AND METHODOLOGY

Table No.-1: Stage wise Methods, Tools and Techniques

Stage -I		Stage - II		Stage -III	
Preparatory Phase		**Collecting Phase**		**Processing & Analysis Phase**	
Planning	**Reviewing**	**Construction of Techniques and Tools for Data Collection & Pilot Study**	**Data Collection**	**Data Processing**	**Data Analyzing & Interpretation**
Selection of research Problem	Book Review	Using available information	Observation	Data gathering, compilation & organization	
Formulation of the Selected Research Problem	Review of Research Work on same place/ same study	Observation, Interviewing & Focus group discussion	Sampling for both physical & socio-economic data	Laboratory Analysis of collected samples & data documentation	
				Various Statistical analysis and presentation with proper statistical software	
Statement of the Research Problem	Review of papers, articles, reports, drafts & historical documents	Administering written data collection tools	Interviewing for specially socio-economic data	Mapping Analysis/ Digital Analysis of Remote Sensing Data: Morphometric, fluviometric , vegetation, soil, land use and other relevant mapping analysis with proper GIS software	
Preparation of Research Design	Review of maps, diagram, image & pictures	Construction of questionnaire and survey schedule & making the attitude scale	Surveying for socio-economic data	Interpretation of all above statistical and mapping analysis	
Time and Expenditure Budget Making	Reviewing & cultivating the previous data	Fixation of sampling techniques, constructing the techniques for instrumental survey,	Photo Documentation as per necessary	Selection, editing and organizing the documented photos/ pictures for ground truth verification	
Collecting and Gathering Secondary Database for Field Survey & Preparation for Survey Tools and Techniques		Emphasizing the Stratified, Systematic and Purposive Sampling Techniques to collect the Required Primary Data and Samples from the Field		Emphasizing the Analysis of IRS and Landsat Imagery and Google Earth Image RS Database, Corresponding Toposheet Collected Primary Data and Secondary Database, etc. with the help of MS Excel, SPSS, Arc GIS 10.1, GPS Software	

Source: Author's Own Construction

Number of Target People for Perception & Causality Study		Collected Soil Samples		Collected Water Samples	
Agricultural Farmers & Others	Fish & Shrimp Cultivators	Fish/ Shrimp Ponds	Adjacent Areas	Fish/ Shrimp Ponds	Adjacent Areas
Total = 152	Total= 203	Total= 153	Total= 153	Total= 102	Total= 102
= 355		= 306		= 204	



Map Plate-4: Distribution of Shrimp Farm and Sampling Sites in the Study Area

Source: Primary Data from Field Survey and Mapping Analysis, 2019-'20

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V. RESULT AND INTERPRETATION

1.1 Changing Scenario of Shrimp Aquaculture along with LULC in Khejuri throughout the Time:

Table No.-2: Spatio-temporal Change in LULC in the Study Area

Major Land use Categories	Spatio-temporal Change (Area in sq. km)						
	1911	1971	2001	2011	2015	2017	2019
Settlement	7.894	15.982	54.300	54.732	57.330	57.890	58.485
Agriculture	224.66	226.383	198.702	197.213	192.823	180.616	176.909
Aquaculture	0.950	1.120	1.870	2.720	4.320	13.055	18.837
Brick Kiln	0	0	0.194	0.341	0.435	0.454	0.752
Forest	22.466	13.068	2.140	2.083	2.092	2.093	2.093
Social Forestry	-	-	0.250	0.245	0.315	0.305	0.403
Inland Natural	1.508	1.312	0.920	1.450	1.540	1.540	1.540
Sandy Area	1.341	0.625	0.390	0.390	0.390	0.390	0.390
River	4.365	4.115	3.990	3.990	3.990	3.990	3.990
Ponds/ Tanks/ Canals	0.475	0.544	0.630	0.654	0.665	0.564	0.503
Others	0.761	1.271	1.040	0.602	0.523	0.523	0.518
Total	264.42	264.42	264.42	264.42	264.42	264.42	264.42
Source:	District Gazette	Historical Records	Block Level Data	District & Block Level Census Data and Image Analysis			

Source: District Gazettes, Historical Records, District Census Report [1], [6], [7], [8], [9], [11], [14], [15], [16] and [17] and Google Earth Image Analysis

Changing Land use Trend of this area is not very exceptional to the global scenario. Changing livelihood status throughout the time influences the land uses and land covers with the upgrading expectations of needy and greedy human beings. Self-orienting human activities are reflected as the signature of changing landscape. In case of my study area, there is also observed this scenario of changing land use/ land cover. The Data (Table No.-2) have been collected and compiled for this purpose which reveals that explosive population growth, haphazard settlement expansion, illegal and capricious human activities and recent development and planning process have compelled to change and modify this coastal landscape. Squeezing behavior of agricultural lands due to changing anthropogenic mind setting towards more beneficial economic activities influences the decline in natural lowland or wetland for different aquatic fresh water living forms. Not only that, establishment and development of brick manufacturing and recent trend towards fish and shrimp farming have encroached the large habitat existence of freshwater fish species along with other aquatic lives. Thus, the changing land use image depicts the turn down look up of natural feeding and breeding field of indigenous fresh water fish species in the study area, Khejuri.

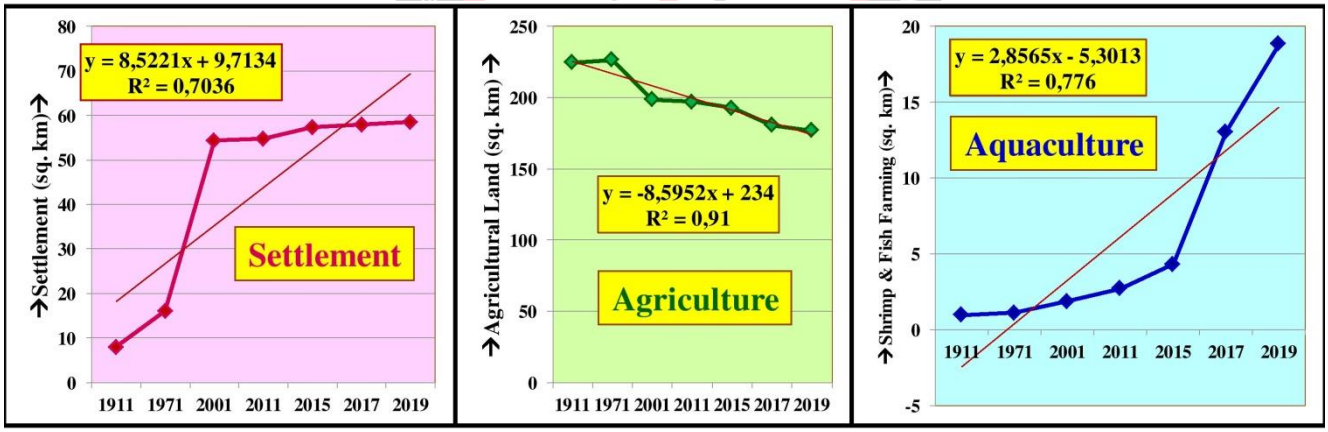

Figure Plate-1: Changing Land use Scenario in the study area
Source: District Gazette, Historical Records, Block and District Level Census Data & Image Analysis

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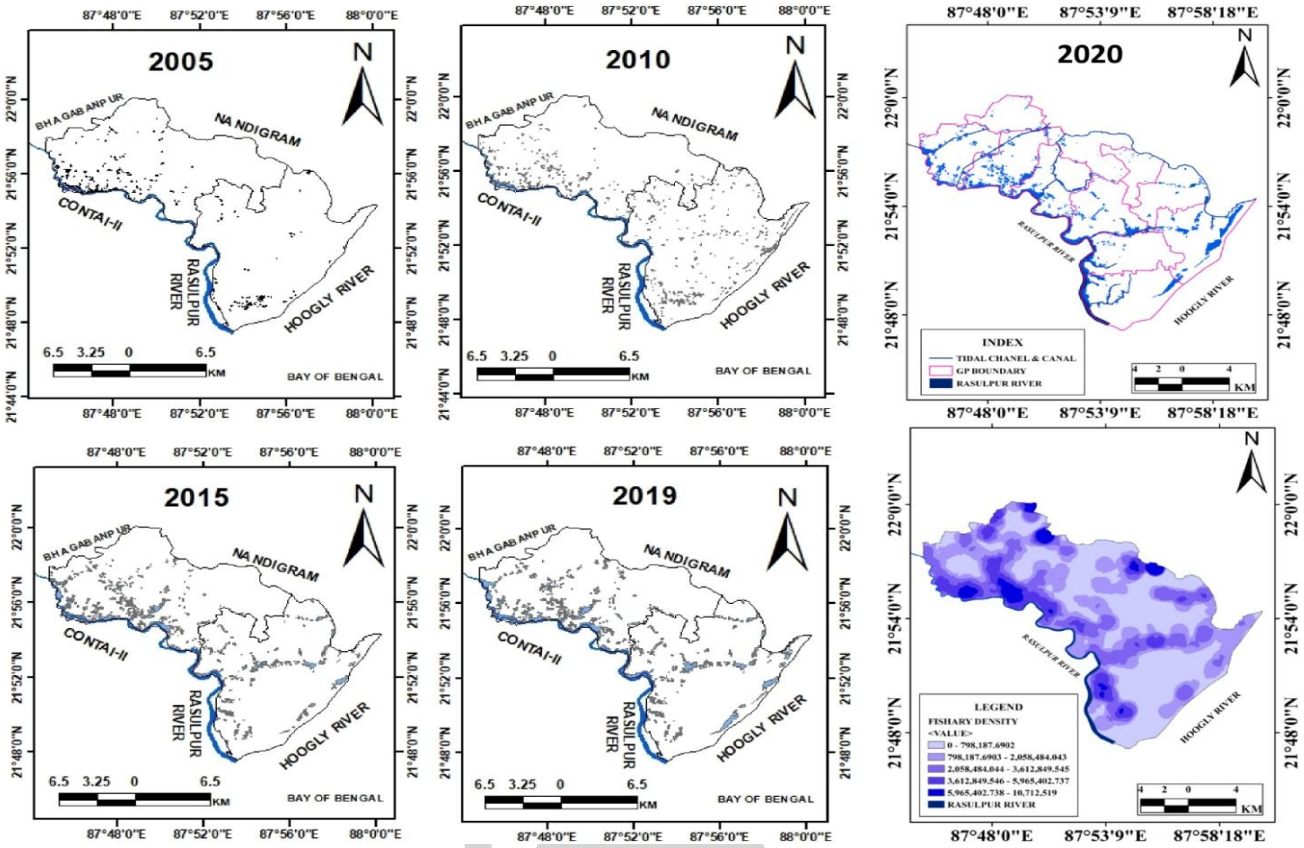

Map Plate-5: Spatio-temporal Change in Shrimp Farming and Its Recent Density in the Study Area

Source: Google Earth Image Analysis (2005, 2010, 2015, 2019 & 2020)

Map Plate-2 shows the variation in spatio-temporal distribution of shrimp culture throughout the study area where spatial sharing of this economy has been concentrating on and along the riverine, channel based, canal side and coastline locations over Hooghly-Rasulpur-Talpati interfluves. Figure Plate-2 indicates, most of the fish ponds have been developed during 2011-2014 period. Out of the spatial entity of shrimp farms, most of these have been exposed from previously existed agricultural land following wetlands and waste lands which have been captured and encroached violating land use and conversion policy of government managing local politics and administration.

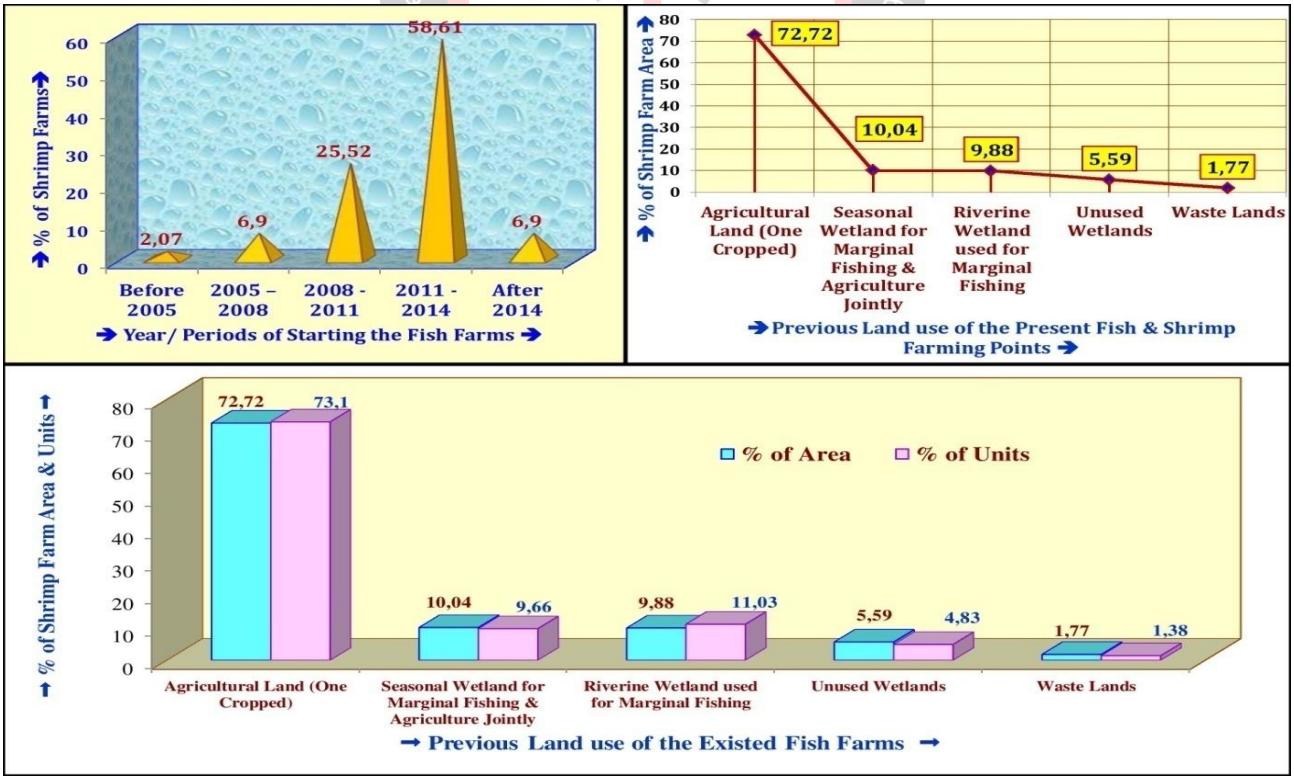

Figure Plate-2: Temporal Growth of Shrimp Farming and Its Past Land use Scenario in the Study Area
Source: Field Survey, 2018-2020

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1.2 Major Responsible Causes for the Massive Growth of Shrimp Aquaculture in Study Area:

On the basis of landscape survey, fishery survey, perception study, specific investigation and secondary database, it is seen that the following causes are more responsible to develop such type of economic practice in the study area:

- Geographical Location: Fluvio-coastal Location & Environment
- Favourable Climate: Mild Sub-tropical Climatic Atmosphere for Shrimp Growth
- Water Availability: Available Water Supply from Tidal River/ Chanel/ Canal & Temporary Mini/ Shallow Tube Well
- Land Availability: Sufficient and Easily Accessible One/ Two Cropped Agricultural Lands
- Infrastructural Development: Remarkable Development in Transport Communication System after 2010
- Market Facility: Regional Market and Opportunity to export easily
- Low Productive Agricultural Lands and Riverine Wetlands
- Very Low/ Marginal Profit from Agriculture and Livestock
- Household Employment Opportunity
- Huge Profit & Human Cost in Short Duration
- Played as Supported & Strengthened Economy
- Govt. Initiatives through different schemes

The Figure-3 prepared from quantitative and qualitative survey indicates the driving factors as well as responsible causes for the massive growth and expansion of shrimp culture in the study area throughout the time. The above mentioned causes have been dignified by the respondents at higher scale of feedback. Very low and marginal profit or loss in agriculture and livestock sufficient land and water availability, huge short term economic gain and human benefit and strengthening indicator of supported economy are the major responsible factors as per intensive sense of survey.

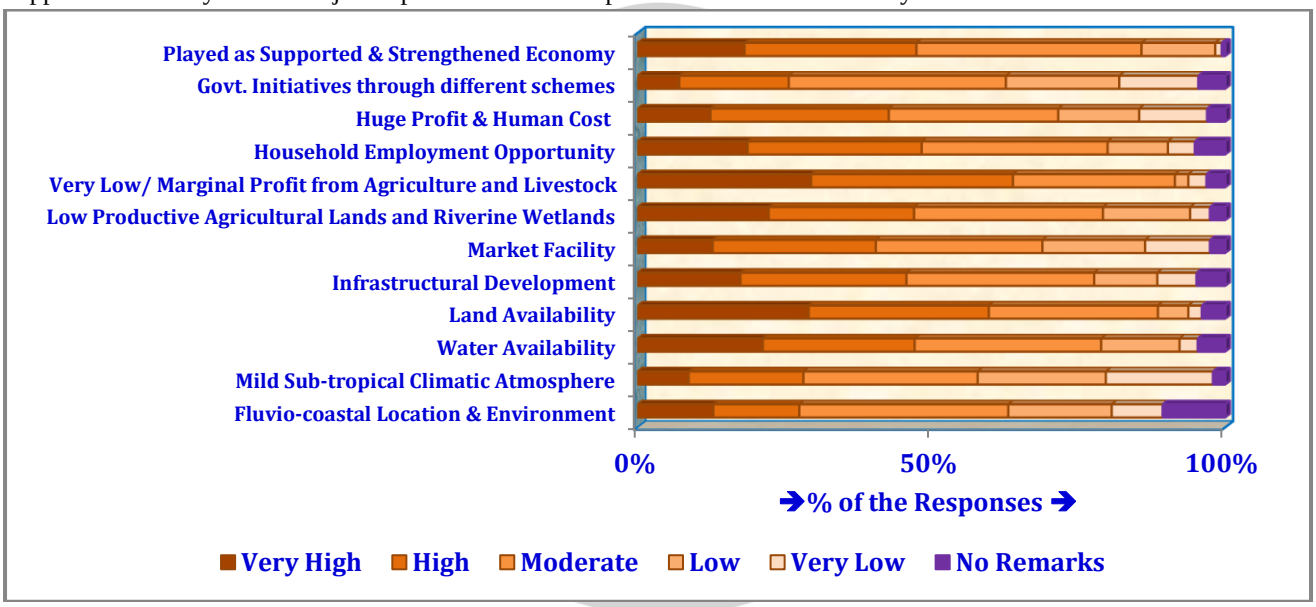

Figure-3: Magnitude of perceived causes responsible for shrimp cultivation in the study area

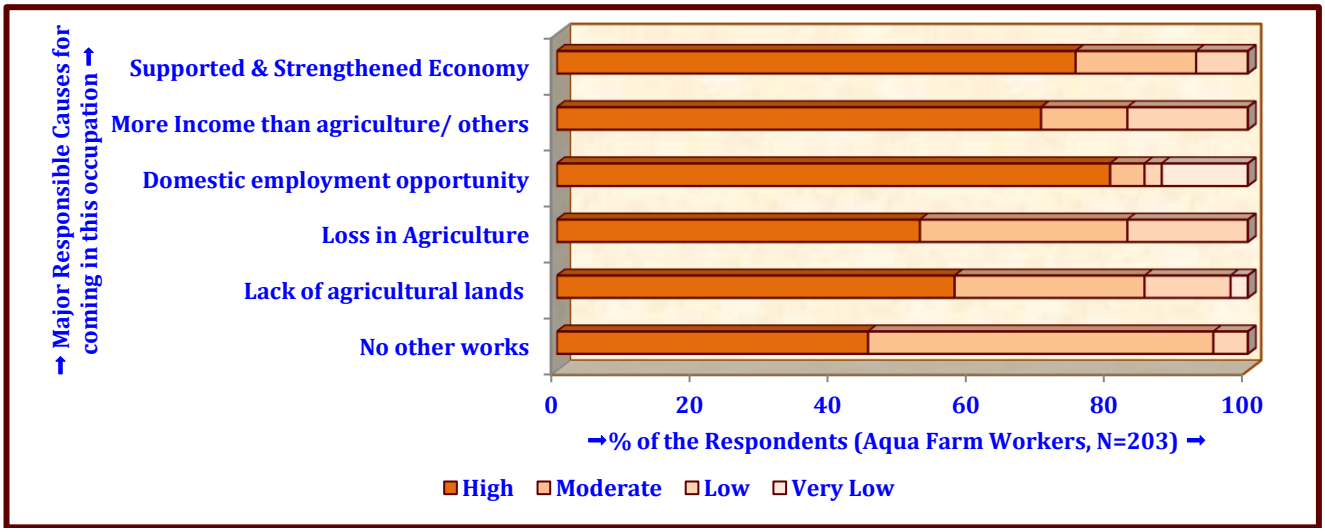

Figure-4: Major responsible causes of the employees for coming in this occupation

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The Figures- 4 reflects the major responsible causes of the employees and workers for coming in this occupation. The perception study reveals that domestic employment opportunity, acted in the role of supported strengthened economy and more income than agriculture and other occupations are the driving causes why the people are more interested to come in such occupation. Loss in recent agriculture and unemployment scenario are also responsible behind the fact.

Table No.-3: Engaged People in Shrimp Aquaculture with respect to Other Workers in the Study Area

Categories of Workers	Male		Female		Total	
	Number	%	Number	%	Number	%
Agricultural Workers	45357	58.27	11962	58.97	57319	58.41
Household Industry Workers	2368	3.04	1356	6.68	3724	3.80
Aquacultural Workers*	**9679***	**12.44**	**614***	**3.03**	**10293***	**10.49**
Others	20436	26.25	6353	31.32	26789	27.30
Total	**77840**	**100**	**20285**	**100**	**98125**	**100**
Total Population	**139788**	**-**	**132667**	**-**	**272455**	**-**

N.B.: Without above figure of aquacultural workers, there are hundreds of floating workers who are indirectly related to this activity along with their base occupation.

Source: Compilation of Secondary Data from Census of India, 2011 [7] and Gram Panchayet and Block Level Reports, 2019-'20*

Table No.-3 reflects the work and worker scenario in the study area where more than ten thousands of people are actively engaged in this life earning way selecting their main source of income in the household. 10.5 % of population is incorporated with aquaculture along with floating 1-2% from other activities. This scenario indicates the upgrowing importance of the blue economy following agriculture in the region.

1.3 Profit Budget Analysis and Productivity Index Analysis in favour of Shrimp Farming Growth:

5.3.1 Shrimp Farming Profit Budget Analysis:

Table No.-4: Shrimp Culture Profit Budget Analysis

Expenditure (Rs./-) from Shrimp Culture per Average Size of Unit/ Point/ Pond/ Farm (1400-1500 sq. ft. ≅ 2-katha) in the Study Area

Initial cost (Rs./-)		Producing cost (Rs./-)		Labour cost (Rs./-)		Others cost (Rs.-)	
Land preparation	35000	Seed brought	45000	Total labour cost (Initial to after production)	70500	Packing, Transporting & Marketization	2500
Fertilizer	14500	Feeding, Vitamins & Other Nutrients	275000			Machines, other tools & accessories	30000
Water supply during season	2000	Oxygening & Related Activities	78500			Land rent	12000
Others	2500	Others	2000			Others	2000
Total	**54000**	**Total**	**400500**	**Total**	**70500**	**Total**	**46500**
Total Expenditure (Rs./-)	**571500**						
Total Output (Rs./-)	**900000 (≅ 30 Quintal @ Rs. 30000/-)**						
Profit (Rs./-)	**Average Profit = Total Output – Total Expenditure = 900000 – 571500 = 328500**						

Source: Field Survey, 2019-'20

Table No.-5: Agriculture Profit Budget Analysis

Expenditure (Rs./-) from Agriculture per Same Size like Shrimp Unit/ Pond/ Point/ Farm (1400-1500 sq. ft. ≅ 2-katha) in the Study Area

Initial cost (Rs./-)		Producing cost (Rs./-)		Labour cost (Rs./-)		Transport cost (Rs./-)	
Seed brought	250	Fertilizer and pesticide	680	Initial to during	1280	Transport	200
Land preparation	400	Water supply (Conditional)	300	After production	1280	Others cost	650
Total	**650**	**Total**	**980**	**Total**	**2560**	**Total**	**850**
Total Expenditure (Rs./-)	**5040**						
Total Output (Rs./-)	**3750**						
Profit (Rs./-)	**= Total Output – Total Expenditure = 3750 – 5040 = -1290 (Loss)**						

Source: Field Survey, 2018-'20

The above profit budget analysis (Table-4 and 5) shows the higher profit scenario from shrimp culture than agriculture and the amount of profit (Rs. /-) about 40 (39.7) times higher than agriculture. Here lies the root causal interest why economic man is more interested and intended in such type of economic practice. It should be notified that in case of micro scale and small scale cultivation, instead of profit, loss is drawn mostly whereas marginal profit is reflected on moderate scale and in case of large and very large scale cultivation; it may be drawn as moderate to higher profit; but not like aquaculture in anyway.

5.3.2 Productivity Index (PI) Analysis:

Productivity Index (PI) = Total Output/ Total Input

Productivity Index (PI) for Agriculture = 3750/5040 = 0.74

Productivity Index (PI) for Aquaculture = 900000/571500 = 1.57

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The above productivity analysis reflects the productivity index in cases of agriculture and aquaculture. Aquaculture, in the study area, draws higher productivity index (1.57) which is 2.12 times of agriculture (0.74) which signifies the dignity of shrimp cultivation than agriculture economy in the study area.

5.3.3 Labour Weighted Production Index (LWPI) Analysis:

Labour Weighted Production Index (LWPI) = (D × LP × T)/ Output

Where,

D = Time of activity/ Day

LP = Labour Power

T = Total Day

Calculation:

LWPI for Agriculture = (8×100×25)/ 20000 = 1 hr./ Unit

(D = 8 hrs., LP = 100, T = 25 and Output = 20000)

LWPI for Aquaculture = (24×100×25)/ 6000000 = 0.1 hr./ Unit

(D = 24 hrs., LP = 100, T = 25 and Output = 6000000)

Required for 1 unit amount of production:

In agriculture, 1 unit amount produced in 1 hour where in aquaculture, 1unit amount of production produced in 0.1 hour at the study area.

LWPI is another measure for dignifying the aquaculture in the study area. Here, this index is very much low in case of aquaculture (0.1 hr/ unit) than agriculture (1 hr/ unit) which indicates the better production scenario of shrimp and fish farming in the study area.

1.4 Impact Assessment Shrimp Farming in the Study Area:

As per observation, investigation and survey throughout the study area from 2018 to 2020, there are existed a lot of negative impacts drawing the environmental and human costs (Table Nos. -6 and 7) in the region whereas several positive impacts (Table No.-6) in terms of short term economic gain have been popularized to accelerate this culture over time.

Table No.-6: Existed Major Impacts as per Survey

Observed Negative Impacts	Observed Positive Impacts
Declining the quality and quantity of agricultural lands;	Generation of employment opportunities
Drastically change in local as well as regional land use pattern;	
Short-term economic gain, but long term impacts in human life style and their socio-economic environment;	Improved standard of living in rural areas
Encroachment and Deterioration of wetland as well as coastal ecosystem by Illegal and haphazard expansion of this economic practice;	Better infrastructure facilities in rural areas
Ecological dwindling including extensive degradation of soil, water and bio resources;	Utilization of saline barren land
A large affection in indigenous aquatic fresh water species diversity;	
A large impact on live stock activities and economy due to dramatic reduction in grazing fields;	Opportunity to develop cyclone and tidal wave affected areas
Creating societal degradation in and around farm atmosphere;	
Salinisation of water source & surrounding land	Increased revenue to the government
Obstruction of drainage & creating flood prone situation	No air pollution & Less pollution comparing to agriculture
Habitat destruction & loss of biodiversity	
Alterations in traditional ecology and livelihood systems	Earning valuable foreign exchange
Chemical and pesticide pollution and Spread of fish diseases	
Destruction of marine fishery resources	Improved health care due to increased wealth
Unemployment of landless labourers & Alienation of small and marginal farmers	

Source: Compilation of Secondary Data [2] and Primary Data (Field Survey-2018-2020)

Figure No.-5 and 6 prepared based on qualitative and quantitative survey and analysis; show the major positive environmental and socio-economic impacts in terms of regional benefits to the study area. Effective uses of low productive aqua fields, riverine wetlands and lowlands and different types of waste and unused lands in terms of shrimp culture draw the accelerator of its expansion here whereas short term, but large scale economic gain, domestic employment, infrastructural development, increasing standard of leaving, dignifying socio-economic positions, opportunity to diversify the side business/ economy, etc. indicates the positive aspects of this life earning way from socio-economic background

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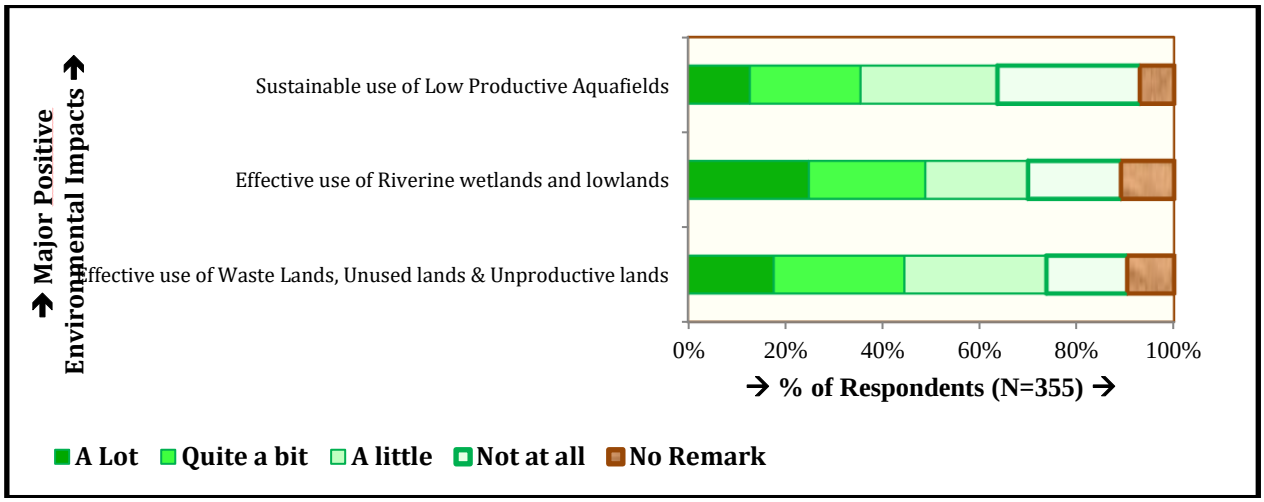

Figure-5: Major Positive Environmental Impacts of Shrimp Cultivation
Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020

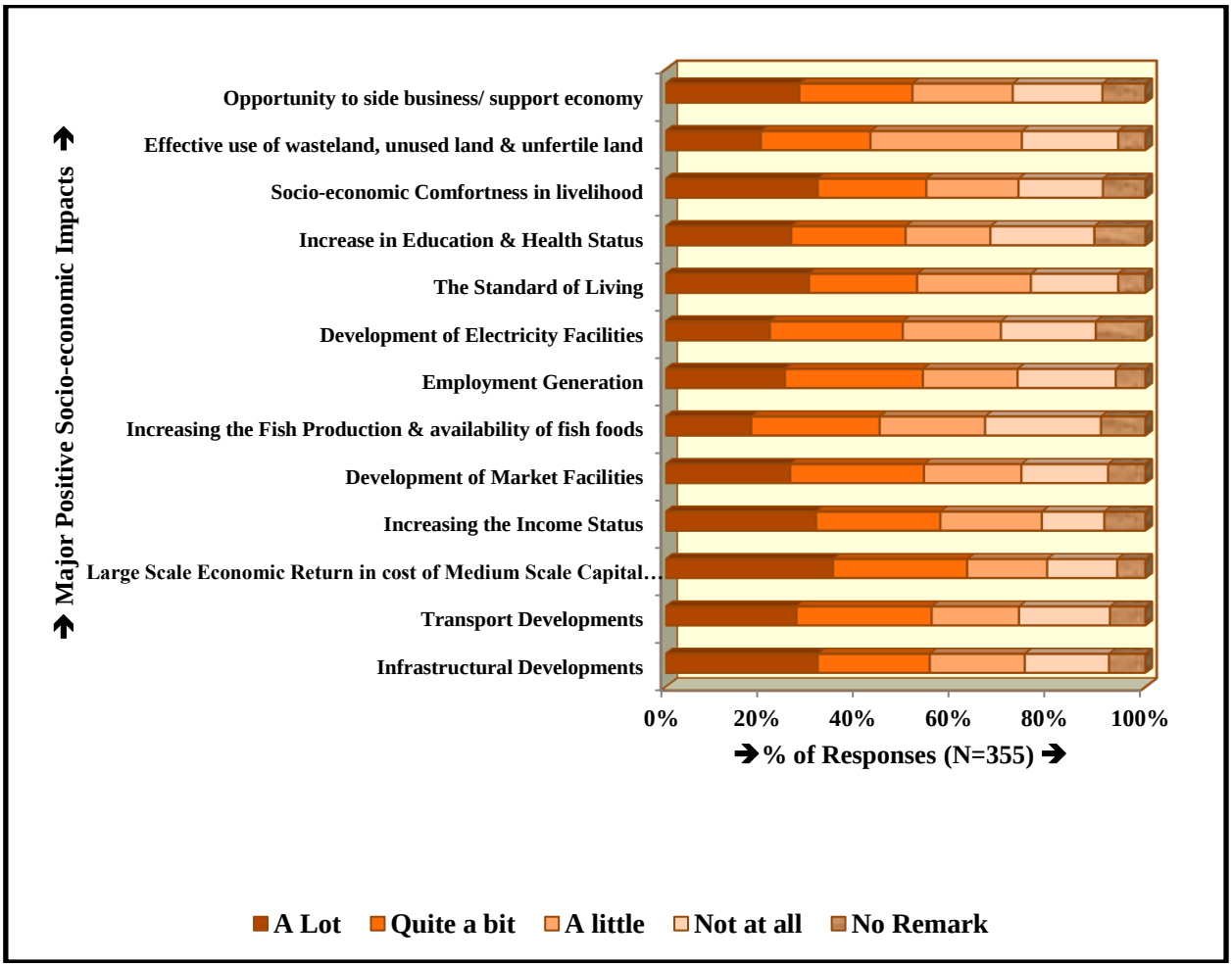

Figure-6: Major Positive Socio-economic Impacts of Shrimp Cultivation
Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020

Table No. -7: Nature of Negative Impacts due to Shrimp Cultivation in Khejuri

Physical Negative Impacts	Physical-Anthropogenic Negative Impacts	Anthropogenic Impacts
Dwindling the indigenous freshwater fish species	Change in food chain & food habits in society & environment	Crisis of fish food as well as fish protein
Declining the aquatic species diversity Decreasing the aquatic biodiversity	Affection of co-species, population & communities including human beings	Changing food lifestyle & livelihood
Declining and degrading the natural aquatic ecosystem & habitat	Change and modification in agricultural ecosystem & practices	Economic loss to dependent root level people & improving
Land degradation in and around the fish/ shrimp farms	Declining the rural grazing lands & depriving the livestock opportunity	The local poverty and unemployment
Soil degradation in and around the fish/ shrimp	Declining the fish resources and related aquatic and	Loosening the socio-cultural, ethical &

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farms	terrestrial characters including human self	aesthetic value centering the mentioned fish species
Change in aquatic food chain and food web		
Emergence of fabricating ecosystem and creating the environmental stress	Consequence of fish farms into wasteland units after fulfilling the leased contract	Family based micro employment opportunity creates the pseudo unemployment

Source: Compilation of Secondary Data [2] and Primary Data (Field Survey-2018-2020)

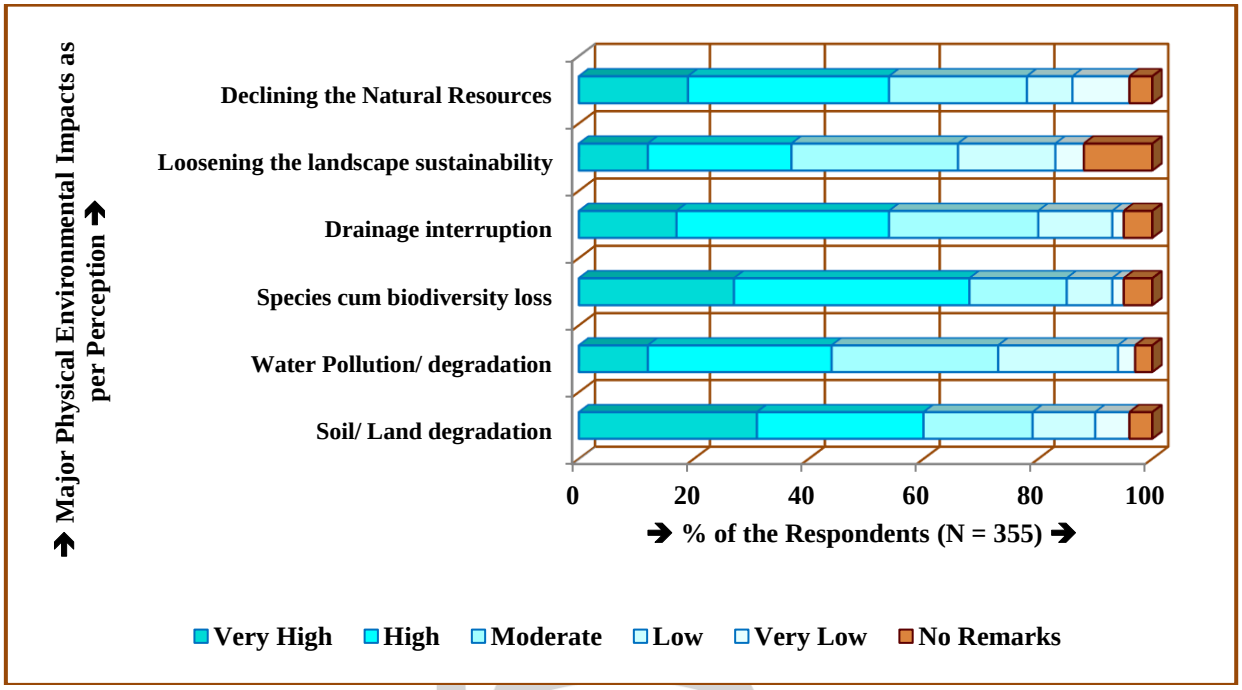
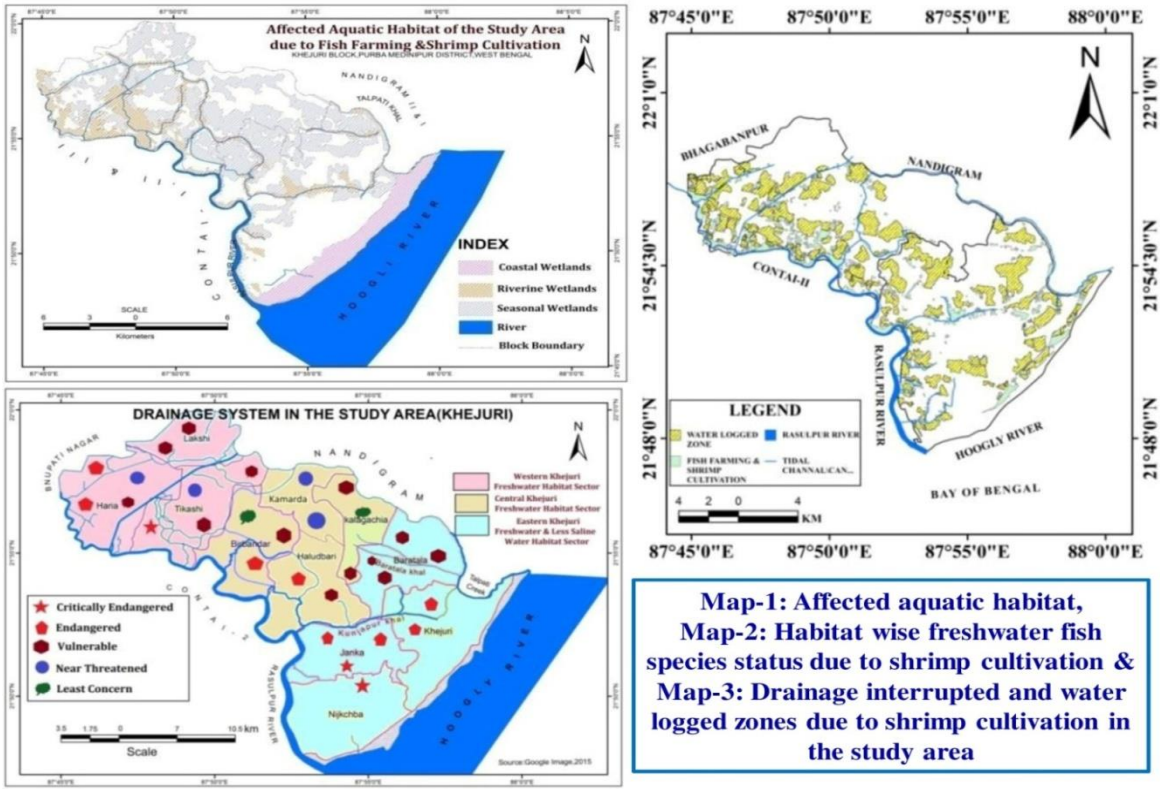


Figure-7: Major Physical Environmental Impacts due to fish farming and shrimp cultivation
Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020



Map Plate-6: Some Physical Environmental Impacts of Shrimp Culture in the Study Area
Source: Data Analysis from GPS Survey, Sampling and Qualitative Field Survey, 2018-2020 and Mapping Analysis

Table No.-8 indicates enlisted major vulnerable freshwater fish species due to large scale shrimp culture in the study area. 31 species has been identified and justified with IUCN Red Book whereas 20 species have undergone into extinct and critically endangered categories (10-species from each). This scenario reflects the most vulnerable situation of indigenous freshwater fish species here

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Table No.-8: Major Vulnerable Freshwater Fish Species due to Aquaculture Expansion in the Study Area

Sl. No.	Name Of Species	Local Name	Scientific Name	Nature Of Existence	Picture
1.	Olive barb	Shorpunti / শর পুঁটি	Puntius sarana	Critically Endangered	
2.	Ticto barb	2-spot barb; Tit punti	Puntius ticto	Endangered	
3.	Rosy barb	কাচোন পুঁটি	Puntius conchonius	Extinct	
3.	Indian glassy fish	Chanda, Lal chanda	Chanda ranga	Critically Endangered	
4.	Elongate glass-perchlet	Chanda, Nama chanda	Chanda nama	Critically Endangered	
5.	Asiatic snakehead	Cheng	Channa orientalis	Extinct	
6.	Mud perch	Meni, Bheda	Nandus nandus	Extinct	
7.	Cuchia	Kuchia	Monopterus cuchia	Extinct	
8.	Pabo catfish	Kani Pabda	Ompok pabo	Extinct	
9.	Keo Fish	Balgura	Platycephalus indicus	Critically Endangered	
10.	Spiny Eel	Raj pankal	Macrognathus siamensis	Critically Endangered	
11.	Snakeskin Gourami	Bhutkori	Trichogaster pectoralis	Extinct	
12.	Orange-fin labeo	কালবাউস	Labeo calbasu	Vulnerable	
13.	Zebra fish	আনঙ্গু	Danio rerio	Extinct	
14.	Gangetic Mystus	Mitha Tengra	Mystus cavasius	Vulnerable	
15.	Dwarf Gourami	Kholisa/ Patkholisa	Colisa lalia	Extinct	
16.	Dwarf Gourami	Kholisa/ Patkholisa	Colisa lalia	Critically Endangered	
17.	Walking catfish	Koi	Anabas testudineus	Vulnerable	
18.	Boga labeo	Bhangan, Bata	Labeo boga	Endangered	
19.	2-track spinyeel	Baim, Salbaim, Bam	Mastacembelus armatus	Critically Endangered	
20.	NA	Singhi	Heteronustes fossilis	Vulnerable	
21.	Cypriniformes Balitoridae	Dari	Schistura scaturigina	Critically Endangered	
22.	Perciformes Gobiidae	Chewa	Pseudapocryptes elongatus	Vulnerable	
23.	Barred spiny eel	Pankal baim	Macrognathus pancalus	Vulnerable	
24.	Wallago	Boal	Wallago attu	Critically Endangered	
25.	Barca snakehead	Pipla shol, Tila shol	Channa barca	Endangered	
26.	Tor mahseer	Mahashol	Tor tor	Extinct	NA
27.	Grey featherback	Foli, Pholi	Notopterus notopterus	Endangered	
28.	Humped featherback	Chital	Notopterus chitala	Critically Endangered	
29.	Tank goby	Bele	Glossogobius giuris	Extinct	
30.		Gachhua	Channa gachua	Extinct	
31.	Mola carplet	Mola	Amblypharyngodon mola	Vulnerable	

Source: Compilation of Primary Data from Qualitative Field Survey, 2018-2020 & Secondary Data [4], [5], [13] and [19]

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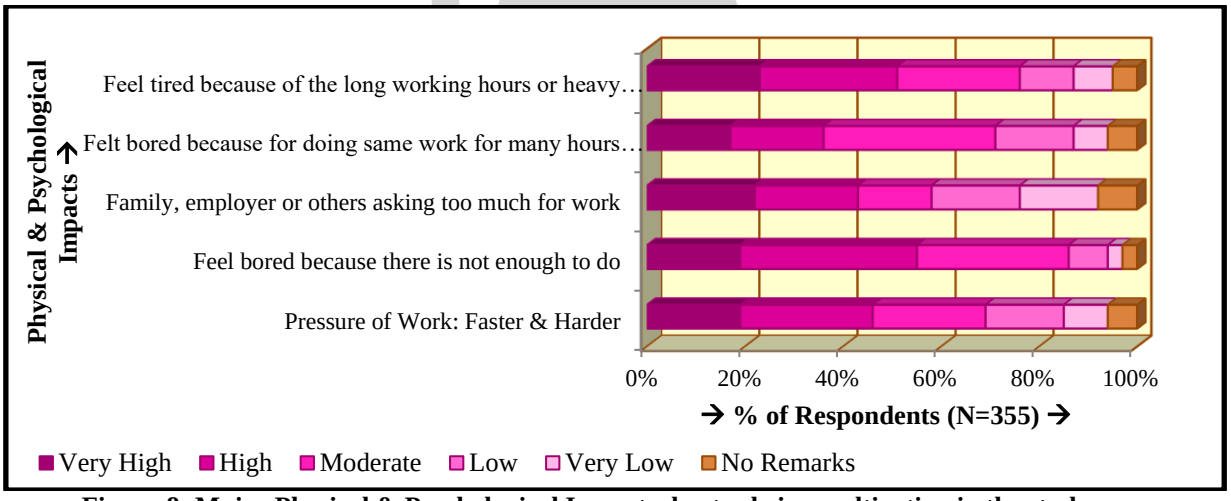

Figure-8: Major Physical & Psychological Impacts due to shrimp cultivation in the study area
Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020

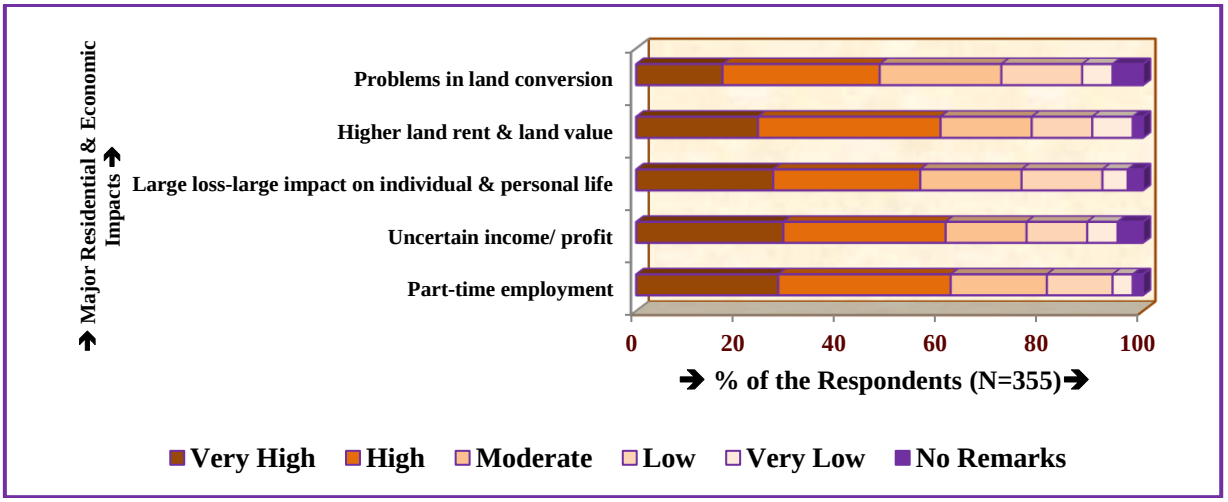

Figure-9: Major Residential & Economic Impacts of shrimp cultivation in the study area

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Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020

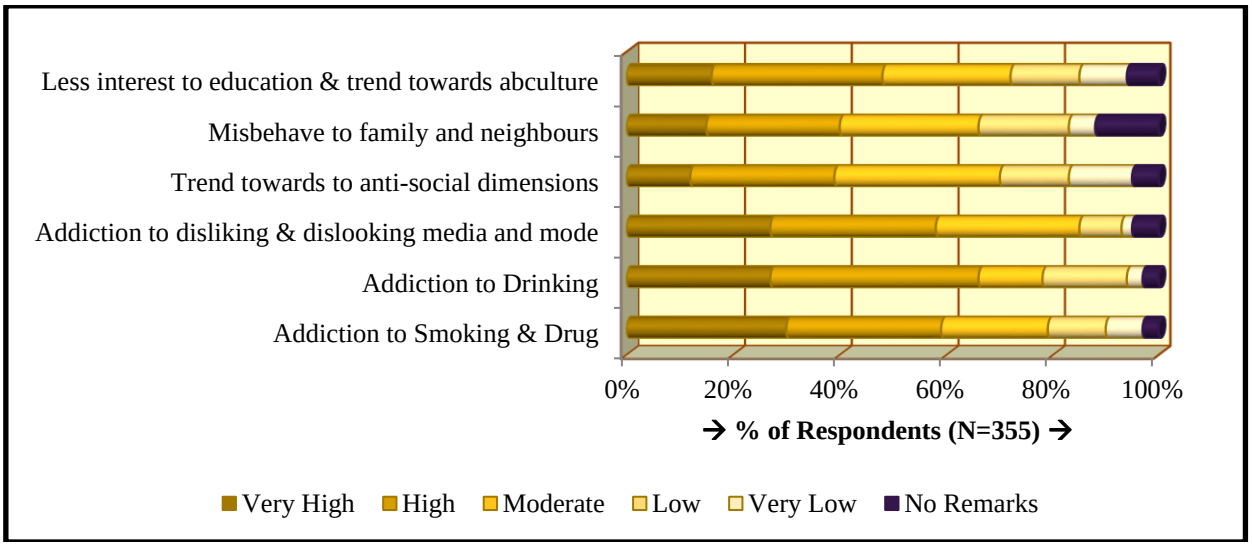

Figure-10: Major Socio-cultural Impacts due to shrimp cultivation in the study area

Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020

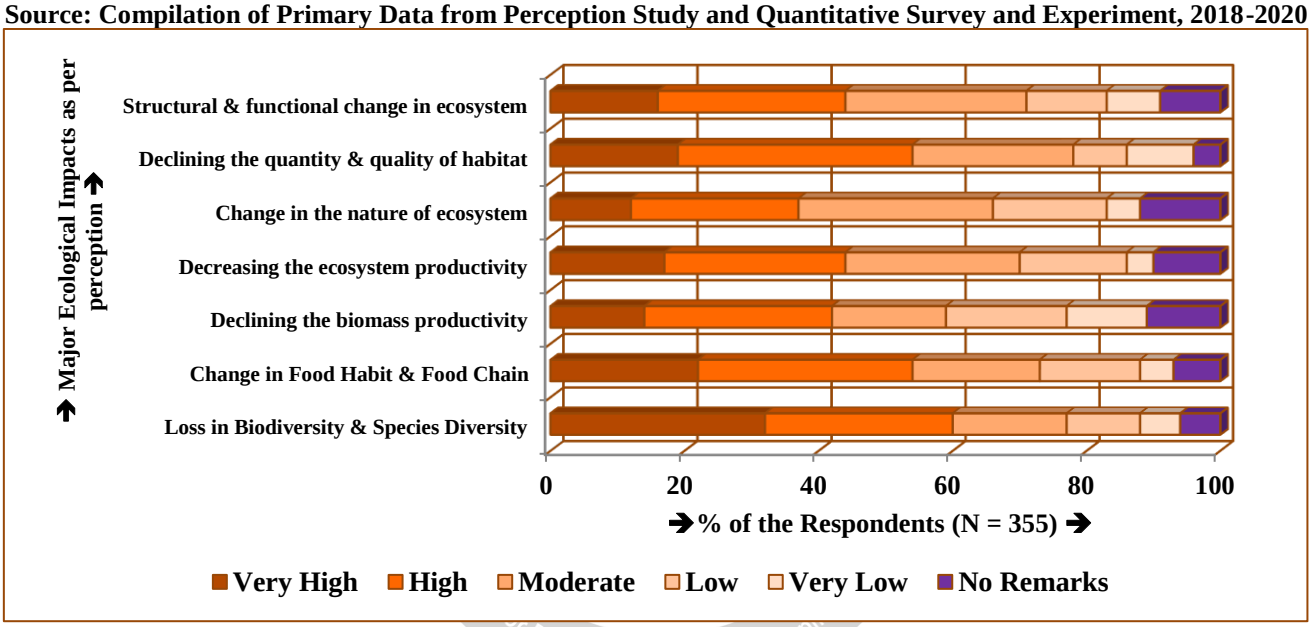

Figure-11: Major Ecological Impacts due to fish farming and shrimp cultivation in the study area

Source: Compilation of Primary Data from Perception Study and Quantitative Survey and Experiment, 2018-2020

The figure-9 shows the major residential and economic costs of fish and shrimp culture rather than the benefits of it. The survey indicates some negative residential and economic impacts like part-time and uncertain employment opportunity, uncertain income or profit, eventual loss and large impacts on individual and family life and livelihood, intensively market based economy rather than local demands, higher land cost and rent for this practice, problem in land conversion, unskillful and untrained practice and lower production and loss, etc. Although, the short term economic and residential benefits are higher from external point of view, but long term impacts regarding those are very significant. The specific and perception study also reflects the very high and higher magnitude of those impacts throughout the study area.

The figure-10 prepared based on the perception study and specific interviews, indicates the major socio-cultural impacts due to shrimp farming in the study area. The study reveals several socio-cultural dimensions which have been influenced by such type of economic practices here. Addiction to smoking and drug like substances, alcoholism, misbehaving to the family, neighbourhoods and others, abusing and misusing the social media, decreasing the interests towards education, increasing trend towards abculture, etc. have been the major negative socio-cultural outcomes incorporating the early younger, young and mature generation specifically. These socio-cultural costs are more prominent than that of its positive returns to engaged families and belonging society. The survey done reflects the very high and high magnitude of impacts throughout the study area.

The collected data and prepared figure-11 reflects the major ecological impacts due to shrimp cultivation in the study area. Loss in biodiversity and species diversity, change in food habit and food chain, declining the biomass productivity, decrease in ecosystem productivity, change in nature, function and behavior of ecosystem, declining the quality and quantity of habitat and

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its livability, etc, are the major ecological costs for such type of economic practice on the fluvio-coastal landscape. The perception study and specific interview show the very high and high magnitude of responses for dignifying its happening.

5.5 Comparative Cost-Benefit Analysis for Aquaculture and Agriculture in the Study Area:

5.5.1 Aquaculture Cost Index (CI_{AQ}) Analysis:

Table No.-9: Aquaculture Cost Index (CI_{AQ}) Analysis

Types of Costs	Major Dimensions	Indicators/ Variables/ Attributes	Weighted Values (5)	Total Weighted Values	Dimension Specific Indices	Cost Specific Index	Aquaculture Cost Index
Environmental Costs	Resource Dimension	Unfortunate Resource Generation & Utilization	3.5	21.5/ 25	Resource based Environment Cost Index (ECI_R) = 0.86	Environment Cost Index (ECI) ($ECI_R + ECI_E$)/ 2 = (0.86 + 0.86)/ 2 = **0.86**	Shrimp Farming Cost Index (CI_{AQ}) = (ECI + HCI)/ 2 = (0.86 + 0.79)/ 2 = **0.825 (82.5%)**
		Resource Abuse, Misuse & Overuse	4.5				
		Resource (Soil, Water, Biotic, etc.) Degradation	4.5				
		Lack in Resource Reuse, Renewability & Recycling	4.5				
		Poor Resource Management & Conservation	4.5				
	Ecological Dimension	Ecosystem: Change & Modification	5.0	21.5/ 25	Ecology based Environment Cost Index (ECI_E) = 0.86		
		Biomass & Productivity Loss	3.5				
		Habitat Loss	4.5				
		Species Declination	4.5				
		Mining Landscape Ecology	4.0				
Human Costs	Socio-economic Dimension	Agricultural Land Loss, Degradation & Defertilization	4.0	15/ 20	Socio-economic Human Cost Index (HCI_{SE}) = 0.75	Human Cost Index (HCI) ($HCI_{SE} + HCI_{SC} + HCI_I$)/ 3 = (0.75 + 0.80 + 0.83)/ 3 = **0.79**	
		Livestock Dilution & Fate on	3.5				
		Pseudo and Part-time Employment & Emigration	3.5				
		Uncertain & Unsecured Economy	4.0				
	Socio-cultural Dimension	Alcoholism, Smoking & Drug Trending	4.5	12/ 15	Socio-cultural Human Cost Index (HCI_{SC}) = 0.80		
		Educational Turndown	4.0				
		Socio-cultural Disruption leading Behavioural Change	3.5				
	Institutional/ Organizational Dimension	Politics rather than Policy	4.0	12.5/ 15	Institutional Human Cost Index (HCI_I) = 0.83		
		Impassivity in Administrative Liability for Illegal Spread of Economy	4.5				
		Incoherence in Land use Policy	4.0				

Cost Index Categories:
(1) CI = 0-0.20: Low Cost, (2) CI = 0.20-0.40: Low to Moderate, (3) CI = 0.40-0.60: Moderate Cost, (4) CI = 0.60 – 0.80: Moderate to High Cost, (5) CI = 0.80 – 1.00: Very High Cost, (7) CI = 0: No Cost and (8) CI = 1.00: Absolute Cost

Source: Compilation of Collected Primary Data, Experimented Result of Collected Sample, Categorical Impact Observation, Survey and Assessment and Perception Study, 2018-2020

The Table No.-9 regarding Aquaculture Cost Index (CI_{AQ}) analysis shows the dimension specific and cost specific indices estimated from the weighted values on various responsible variables or attributes under different dimensions quantitatively and qualitatively surveyed and experimented in this study. In case of the dimension specific indices, the values are greater than 0.80 excluding socio-economic human cost index (HCI_{SE} = 0.75) only which indicates the high to very high magnitude of impacts. The analysis reflects that Environmental Cost Index (ECI) is higher (ECI>HCI i.e., 0.86>0.79) than Human Cost Index (HCI) whereas ECI belongs to very high impact on environment and HCI shows higher impacts on human dimensions. Hence, the Shrimp Farming Cost Index (CI_{AQ}) is 0.825, i.e., 82.5% which signifies the acute cost to society and environment by shrimp culture in the study area.

5.5.2 Aquaculture Benefit Index (BI_{AG}) Analysis

Table No.-10: Aquaculture Benefit Index (BI_{AG}) Analysis

Types of Costs	Major Dimensions	Indicators/ Variables/ Attributes	Weighted Values (5)	Total Weighted Values	Dimension Specific Indices	Benefit Specific Index	Aquaculture Benefit Index
Environmental Benef	Resource & Ecological Dimension	Functionalized Use of Fluvio-coastal Site Suitability/ Environment	3.0	11.5/ 20	gy based Environment Benef	nt Benef it Index (BI_{AQ}) = (EBI + HBI)/	

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		Effective Use of Unused, Rejected & Waste lands	3.0				
		Proper Utilization of Low Productive Wetlands, Lowlands & Agricultural Land	3.0				
		Effective use of Low Productive Ecosystem	2.5				
Human Benefit	Socio-economic Dimension	Large Scale Economic Return and Profit	4.0	23/30	**Socio-economic Human Benefit Index (HBI_{SE})** = 0.77	**Human Benefit Index (HBI)** ($HBI_{SE} + HBI_{SC} + HBI_I$) / 3 = (0.77 + 0.75 + 0.60)/ 3 = **0.71**	
		Short Term Economic Gain, Higher Income, Saving Opportunity & Quick Growth	4.0				
		Domestic & Local Employment Opportunity	3.5				
		Developing Market Facilities & Infrastructure	3.5				
		Increasing Living Standard & Upgrading Livelihood	4.0				
		Strengthening Supported Economy and Economic Security	4.0				
	Socio-cultural Dimension	Promoting Socio-cultural Status like Education, Health & Consumption of Different Modern Amenities	4.0	15/ 20	**Socio-cultural Human Benefit Index HBI_{SC})** = 0.75		
		Developing housing, sanitation, demand and consumption	4.0				
		Dignifying Socio-cultural Position in the Society	3.5				
		Change in Food, Nutrition, Clothing and Behavioural Cases	3.5				
	Institutional/ Organizational Dimension	Strengthening Policy and Providing Training, Education, Loan Facility & Emergent Subsidy from Govt. Horizon	3.0	6/ 10	**Institutional Human Benefit Index (HBI_I)** = 0.60		
		Strengthening Owners' and Labours' Organization in Self of Their Livelihood & Economy	3.0				

Benefit Index Categories:
(1) BI = 0-0.20: Low Cost, (2) BI = 0.20-0.40: Low to Moderate, (3) BI = 0.40-0.60: Moderate Cost, (4) BI = 0.60 – 0.80: Moderate to High Cost, (5) BI = 0.80 – 1.00: Very High Cost, (7) BI = 0: No Cost and (8) BI = 1.00: Absolute Cost

Source: Compilation of Collected Primary Data, Experimented Result of Collected Sample, Categorical Impact Observation, Survey and Assessment and Perception Study, 2018-2020

The Table No.-10 belonging Shrimp Farming Benefit Index (BI_{AQ}) analysis gives the idea about positive returns from shrimp culture. This analysis shows the low to moderate environmental benefits (EBI = 0.57) whereas human benefits is more (HBI = 0.71) and comprehensive scenario reflects the nearly moderate to higher trend (BI_{AQ} = 0.64) of benefits from this occupation in the study area.

5.5.3 Cost-Benefit Index (CBI_{SF}) or Benefit-Cost Ratio (BCR_{AQ}) Analysis for Aquaculture

Table No.-11: Cost-Benefit Index (CBI_{SF}) or Benefit-Cost Ratio (BCR_{AQ}) Analysis for Aquaculture

Cost Index		Benefit Index		Environmental Cost-Benefit Index (ECBI)	Human Cost-Benefit Index (HCBI)	Cost-Benefit Index (CBI_{AQ})
ECI	**HCI**	**EBI**	**HBI**			
0.86	0.79	0.57	0.71	EBI/ECI = 0.66	HBI/ HCI = 0.90	$\{(EBI + HBI)/2 \mid (ECI + BCI)/2\}$
Average CI = 0.83		Average BI = 0.64				= 0.64/0.83 = **0.77**

Source: Analysis of Compiled Data

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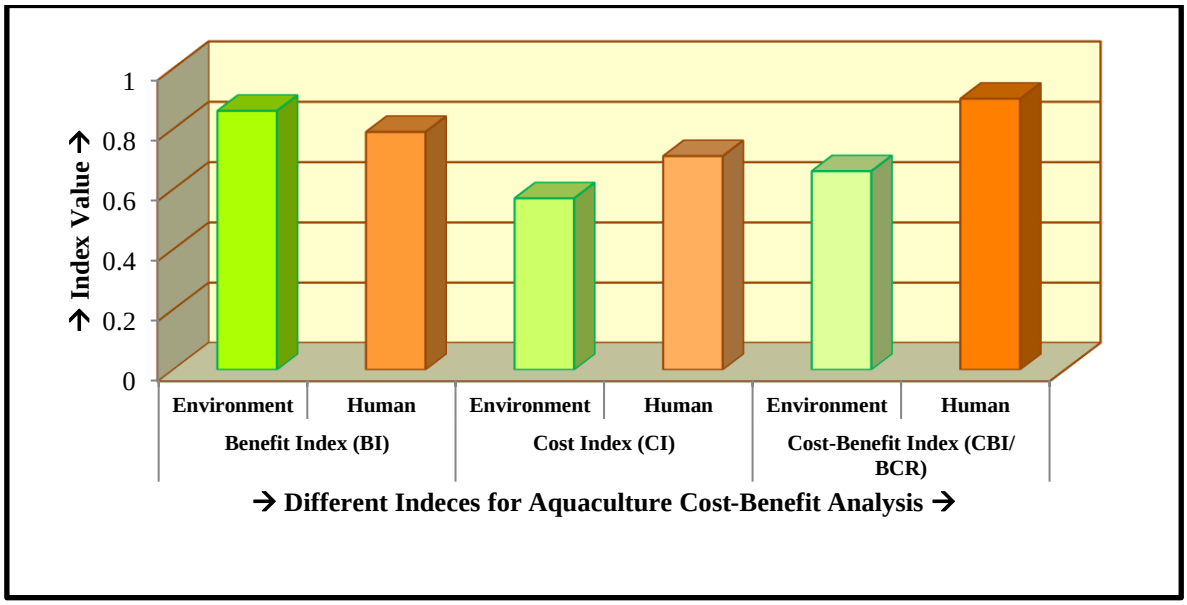

Figure No.-12: Comparative Scenario of Benefit, Cost and Cost-Benefit Indices

The Table No.-11 depicts the compilation and synthesis of Table Nos. - 8 and 9 having Cost Indices and Benefit Indices of shrimp farming in the study area. The table -10 estimates the Cost-Benefit Index (CBI) or Benefit-Cost Ratio (BCR) from environmental, human and comprehensive points of view. Environmental Cost-Benefit Index (ECBI) and Human Cost-Benefit Index (HCBI) show the experimented values like 0.66 and 0.90 whereas both are below 1.0. This assessment indicates very poor situation in cost-benefit drawing leading environmental negative impacts and poor or marginal human benefits with respect to its costs.

5.5.4 Agriculture Cost Index (CI_{AG}) Analysis:

Table No.-12: Agriculture Cost Index (CI_{AG}) Analysis

Types of Costs	Major Dimensions	Indicators/ Variables/ Attributes	Weighted Values (5)	Total Weighted Values	Dimension Specific Indices	Cost Specific Index	Agriculture Cost Index
Environmental Costs	Resource Dimension	Unfortunate Resource Generation & Utilization	2.5	16/ 25	Resource based Environment Cost Index (ECI_R) = 0.64	Environment Cost Index (ECI) ($ECI_R + ECI_E$)/ 2 = (0.64 + 0.64)/ 2 = **0.64**	Agriculture Cost Index (CI_{AG}) = (ECI + HCI)/ 2 = (0.64 + 0.49)/ 2 = **0.565 (56.5%)**
		Resource Abuse, Misuse & Overuse	3.0				
		Resource (Soil, Water, Biotic, etc.) Degradation	3.5				
		Lack in Resource Reuse, Renewability & Recycling	3.5				
		Poor Resource Management & Conservation	3.5				
	Ecological Dimension	Ecosystem: Change & Modification	3.0	16/ 25	Ecology based Environment Cost Index (ECI_E) = 0.64		
		Biomass & Productivity Loss	3.0				
		Habitat Loss	3.5				
		Species Declination	3.5				
		Mining Landscape Ecology	3.0				
Human Costs	Socio-economic Dimension	Land Loss, Degradation & Defertilization	3.0	11.5/ 20	Socio-economic Human Cost Index (HCI_{SE}) = 0.58	Human Cost Index (HCI) ($HCI_{SE} + HCI_{SC} + HCI_I$)/ 3 = (0.58+ 0.43 + 0.47)/ 3 = **0.49**	
		Livestock Dilution & Fate on	3.0				
		Pseudo and Part-time Employment & Emigration	3.0				
		Uncertain & Unsecured Economy	2.5				
	Socio-cultural Dimension	Alcoholism, Smoking & Drug Trending	2.0	6.5/ 15	Socio-cultural Human Cost Index (HCI_{SC}) = 0.43		
		Educational Turndown	2.5				
		Socio-cultural Disruption leading Behavioural Change	2.0				
	Institutional/ Organizational Dimension	Politics rather than Policy	2.0	7/ 15	Institutional Human Cost Index (HCI_I) = 0.47		
		Impassivity in Administrative Liability for Illegal Spread of Economy	2.5				

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		Incoherence in Land use Policy	2.5				

Cost Index Categories:
(1) CI = 0-0.20: Low Cost, (2) CI = 0.20-0.40: Low to Moderate, (3) CI = 0.40-0.60: Moderate Cost, (4) CI = 0.60 – 0.80: Moderate to High Cost, (5) CI = 0.80 – 1.00: Very High Cost, (7) CI = 0: No Cost and (8) CI = 1.00: Absolute Cost

Source: Compilation of Collected Primary Data, Experimented Result of Collected Sample, Categorical Impact Observation, Survey and Assessment and Perception Study, 2018-2020

The Table No.-12 regarding Agriculture Cost Index (CI_{AG}) analysis shows the dimension specific and cost specific indices estimated from the weighted values on various responsible variables or attributes under different dimensions quantitatively and qualitatively surveyed and experimented in this study. In case of the dimension specific indices, the values of environmental costs are less than 0.70 whereas human cost indices are in between 0.40 and 0.60 which indicates the lower human costs and moderate environmental costs of agriculture in the study area. The analysis reflects that Environmental Cost Index (ECI) is higher (ECI>HCI i.e., 0.64>0.49) than Human Cost Index (HCI) whereas ECI belongs to moderate impact on environment and HCI shows lower impacts on human dimensions. Hence, the Agriculture Cost Index (CI_{AG}) is 0.565, i.e., 56.5% which signifies the low to medium cost to society and environment by this occupation.

5.5.5 Agriculture Benefit Index (BI_{AG}) Analysis:

Table No.-13: Agriculture Benefit Index (BI_{AG}) Analysis

Types of Costs	Major Dimensions	Indicators/ Variables/ Attributes	Weighted Values (5)	Total Weighted Values	Dimension Specific Indices	Benefit Specific Index	Agriculture Benefit Index
Environmental Benefit	Resource & Ecological Dimension	Functionalized Use of Fluvio-coastal Site Suitability/ Environment	3.0	9.5/ 20	**Resource & Ecology based Environment Benefit Index (EBI_{RE}) = 0.48**	**Environment Benefit Index (EBI) = 0.48**	**Shrimp Farming Benefit Index (BI_{AG})** = (EBI + HBI)/ 2 = (0.48 + 0.49)/ 2 = **0.485 (48.5%)**
		Effective Use of Unused, Rejected & Waste lands	2.0				
		Proper Utilization of Low Productive Wetlands, Lowlands & others	2.5				
		Effective use of Low Productive Ecosystem	2.0				
Human Benefit	Socio-economic Dimension	Large Scale Economic Return and Profit	2.5	16/30	**Socio-economic Human Benefit Index (HBI_{SE}) = 0.53**	**Human Benefit Index (HBI)** (HBI_{SE} + HBI_{SC} + HBI_I)/ 3 = (0.53 + 0.45 + 0.50)/ 3 = **0.49**	
		Short Term Economic Gain, Higher Income, Saving Opportunity & Quick Growth	2.5				
		Domestic & Local Employment Opportunity	4.0				
		Developing Market Facilities & Infrastructure	2.0				
		Increasing Living Standard & Upgrading Livelihood	2.5				
		Strengthening Supported Economy and Economic Security	2.5				
	Socio-cultural Dimension	Promoting Socio-cultural Status like Education, Health & Consumption of Different Modern Amenities	2.5	9/ 20	**Socio-cultural Human Benefit Index (HBI_{SC}) = 0.45**		
		Developing housing, sanitation, demand and consumption	2.5				
		Dignifying Socio-cultural Position in the Society	2.0				
		Change in Food, Nutrition, Clothing and Behavioural Cases	2.0				
	Institutional/ Organizational Dimension	Strengthening Policy and Providing Training, Education, Loan Facility & Emergent Subsidy from Govt. Horizon	3.0	5/ 10	**Institutional Human Benefit Index (HBI_I) = 0.50**		
		Strengthening Owners' and Labours' Organization in Self of Their Livelihood & Economy	2.0				

Benefit Index Categories:
(1) BI = 0-0.20: Low Cost, (2) BI = 0.20-0.40: Low to Moderate, (3) BI = 0.40-0.60: Moderate Cost, (4) BI = 0.60 – 0.80: Moderate to High Cost, (5) BI = 0.80 – 1.00: Very High Cost, (7) BI = 0: No Cost and (8) BI = 1.00: Absolute Cost

Source: Compilation of Collected Primary Data, Experimented Result of Collected Sample, Categorical Impact Observation, Survey and Assessment and

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The Table No.-13 belonging Agriculture Benefit Index (BI_{AG}) analysis gives the idea about positive returns from agriculture. This analysis shows the lower environmental benefits (EBI = 0.48) whereas human benefits is also equivalent and lower (HBI = 0.49) and comprehensive scenario reflects the lower trend (BI_{AG} = 0.485) of benefits from this occupation in the study area.

5.5.6 Cost-Benefit Index (CBI_{AG}) or Benefit-Cost Ratio (BCR_{AG}) Analysis for Agriculture:

Table No.-14: Cost-Benefit Index (CBI_{AG}) or Benefit-Cost Ratio (BCR_{AG}) Analysis for Agriculture

Cost Index		Benefit Index		Environmental Cost-Benefit Index (ECBI)	Human Cost-Benefit Index (HCBI)	Cost-Benefit Index (CBI_{AG})
ECI	HCI	EBI	HBI			
0.64	0.49	0.48	0.49	EBI/ECI = **0.75**	HBI/ HCI = **1.00**	$\{(EBI + HBI)/2 \mid (ECI + BCI)/2\}$
Average CI = 0.83		Average BI = 0.64				= 0.485/0.565 = **0.86**

Source: Analysis of Compiled Data

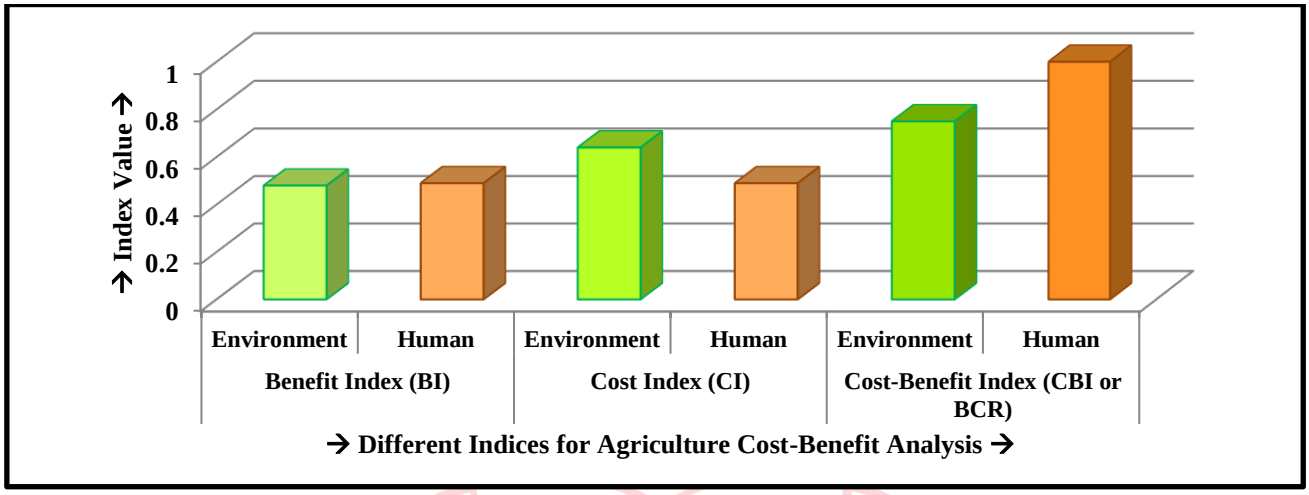

Figure No.-13: Comparative Scenario of Benefit, Cost and Cost-Benefit Indices for Agriculture

Table No.-14 depicts the compilation and synthesis of Table Nos. - 12 and 13 having Cost Indices and Benefit Indices of agriculture in the study area. The table -13 estimates the Cost-Benefit Index (CBI) or Benefit-Cost Ratio (BCR) from environmental, human and comprehensive points of view. Environmental Cost-Benefit Index (ECBI) and Human Cost-Benefit Index (HCBI) show the experimented values like 0.75 and 1.00. This assessment indicates poor situation in cost-benefit leading environmental negative impacts due to modern agricultural system mainly and better situation of human benefits with respect to its costs at the long term scale.

5.5.7 Comparative Scenario of Cost-Benefit Indices for Agriculture and Aquaculture in the Study Area:

Table Nos.-11and 14 and Figure No.-14 show the comparative scenario of Cost-Benefit Indices for agriculture and aquaculture in the study area. The data analysis reveals that environmental cost-benefit is higher in case of agriculture than aquaculture which indicates the higher environmental costs/ impacts of aquaculture here. Further, it is seen that human cost-benefit is also higher in case of agriculture than aquaculture which indicates the higher human costs/ impacts of aquaculture again. It is remarkable that in agriculture human cost-benefit index belongs to 1.0 value which is satisfactory on long term development scale while this is 0.9 in case of aquaculture indicating moderate situation human development instead of huge short term economic gain. Comprehensively, cost-benefit index or benefit-cost ratio of agriculture is higher ($CBI_{AG} > CBI_{AQ}$ = 0.86>0.77) than aquaculture which reflects the lower environmental and human costs in agro-economy and profit is not higher, but average and stabilized on scale. On the other hand, the analysis indicates, the higher environmental and human costs of blue economy draw the backward situation in regional development. Hence, this scenario tells the urgent needs for solo or integrated management of the issue in terms of sustainable aquaculture of sustainable agro-aquaculture in the region.

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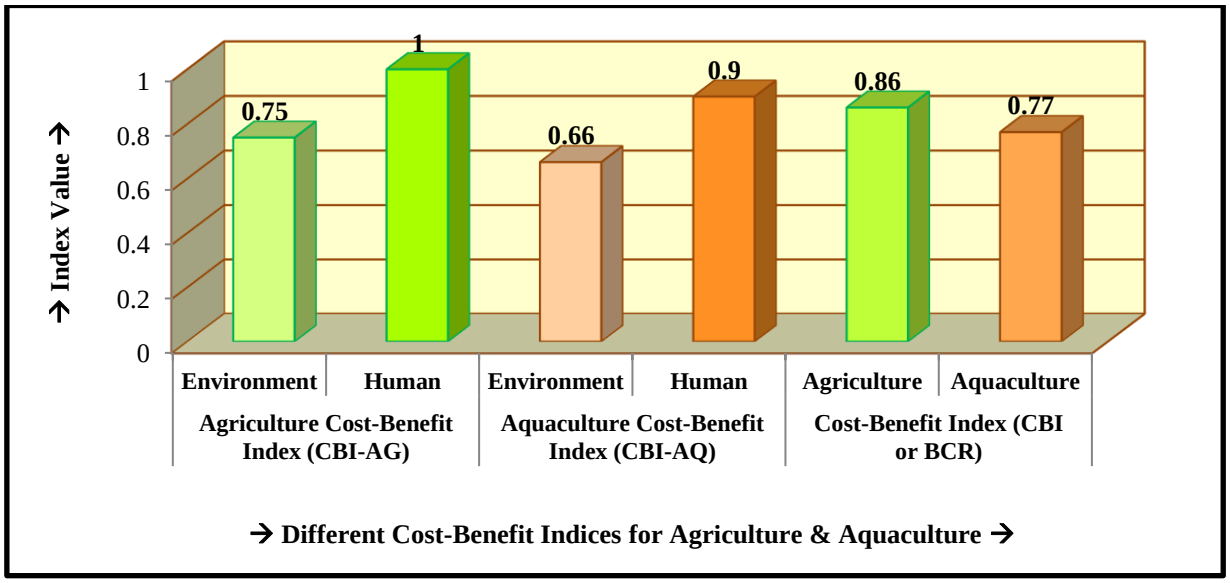

Figure No.-14: Comparative Scenario of Cost-Benefit Indices for Agriculture and Aquaculture in the Study Area

VI. MAJOR FINDINGS

- Site suitability and situation favours for the set up of agro-economy and the growth and expansion of shrimp farming as well as aquaculture.
- Aquaculture flourished as the fastest growing economy occupying the 2nd position from economic sharing after agriculture in the study area
- A large number of people are engaged in aquaculture following agriculture showing the domestic employment opportunity.
- Enormous and drastically LULC change due to aquaculture has been occurred affecting wetlands, vegetation and agricultural lands mainly.
- Most of the fish farms and shrimp ponds are illegal, unauthorized, unscientific, haphazard and unplanned on the track of its journey and development in the region.
- In aquaculture, the short term socio-economic gains and benefits to specific group of people (owner groups) are well observed whereas agriculture draws the long term socio-economic benefits with its stability.
- The environmental, ecological and socio-economic costs are higher in case of aquaculture than agriculture.
- Huge environmental costs include soil and water pollution, biodiversity and species diversity loss, habitat and ecosystem declining and defunctioning and resource dwindling.
- Lack of knowledge, training and research towards providing a layout for the sustainable shrimp cultivation or integrated agro-aquaculture or aqua-agriculture adjusted with regional fluvio-coastal environment is observed.
- Lack of knowledge, training and research towards providing a layout for the micro-level planning & regional development is reflected.

VII. RECOMMENDATIONS

1.5 The recommendation related to Nutrition:

- Undertaking studies on intra-household, intra-regional, intra-national and international consumption of fish by season and prioritize species to be cultured, in consultation with stakeholders;
- Popularizing the consumption of nutrient-dense fish and shrimp species through awareness programmes, and, at the same time, ensuring that the access rights to these species remain with the local communities, by empowering local governments to take decisions on these issues;
- Documenting and exploring the nutritive value and therapeutic properties of fish and shrimp species, also in relation to cooking and eating habits and evaluating the role of the small indigenous freshwater fish species in nutritional security of vulnerable groups, such as pregnant and lactating women and children.

7.2 The key recommendations related to Poverty Alleviation:

- ❖ Recognizing the role of govt. in poverty alleviation, through assessment of their contribution to the economy and nutrition of disadvantaged populations, particularly women and children;
- ❖ Ensuring protection/management of aquatic habitats, while ensuring that the rights of access of disadvantaged groups to aquatic resources are secured;
- ❖ Ensuring that research and policy promote the integration of these species into culture-based fisheries and aquaculture systems; and
- ❖ Strengthening appropriate community institutions to protect access rights ensure responsible ecosystem management and equitable economic benefits.

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7.3 The key recommendations related to Biodiversity:

- ✪ Assessing the freshwater habitat, species richness, endemicity and causes of degradation;
- ✪ Reviewing the adequacy of existing polices, identifying gaps, conflicts, etc., with a view to strengthening policies for conservation of these species;
- ✪ Develop local community awareness, evolve specific recovery programmes with local participation and develop management strategies/models for replication and up scaling.

7.4 The key recommendations related to Legal Policy, Planning and Strategy Making:

- ♠ Ensuring that policy and legislation at different levels on agriculture, aquaculture and biodiversity conservation addresses the development needs and conservation requirements of environment;
- ♠ Developing policy and support system;
- ♠ Preparing Block wise endemic and endangered status reports of small native species;
- ♠ Ensuring that the benefits flow to the local community in case of any commercial utilization of resources;
- ♠ Compiling, documenting, protecting and rewarding farmers' innovations and traditional knowledge in both agriculture and aquaculture;
- ♠ Developing institutional mechanisms to promote culture, consumption and conservation of agro and aqua species;
- ♠ Protecting access rights of local communities, especially women, to the agro-and aqua species, particularly through appropriate policies and legislation that take into consideration the local socioeconomic, cultural and institutional context [12];
- ♠ Documenting and protecting traditional knowledge and farmers' innovation with regard to use of agricultural, aquatic and aquaculture resources [12];
- ♠ Sustainable, low-cost, large scale strategies to increase the management, conservation, production and accessibility of aqua and agro species should be developed and implemented; and
- ♠ Regarding strategy for promotion of aqua and agro species, there is need for planning and research to focus prioritization, further refinement of culture technology and market development.

7.5 Strategy for developing a sustainability approach towards shrimp farming and integrated management:

Table -15: Coping Strategy for developing a sustainability approach towards shrimp farming and integrated management through 4-C Framework, 4-M Techniques and 4-R Policies

4-C Framework towards Sustainability Approach			
Change Detection & Analysis	**Causal Investigation**	**Consequence Assessment**	**Coping Strategy**
All types of changes in morphology, drainage, vegetation, ecosystem, livelihood and lifestyle due to this economic practice should be detected and analysed first.	Factorial cum causal investigation and analysis should be emphasized to know the proper causes for quick development of it throughout the study area.	Environmental and human cost assessment should be considered for better planning and development regarding this occupation here.	Far sighted scientific thinking towards recovery reminding reality, planning the Programmes for public to prime characters, making the blue print linking the people, politician, planner and plan implementer, etc. must be considered as the coping strategy for planning, development and management of this practice.
4-M Techniques towards Sustainability Approach			
M_1: Modeling for Resource Availability, Utilization, Consumption & Conservation	**M_2: Modeling** for Plan Estimation, Labour, Capital and Technological Budget and Plan Implementing Methodology	**M_3: Modeling** for Expected Findings and Problems and Searching Alternatives to fulfill the Plan	**M_4: Modeling** for Risk/ Impact Assessment, Renovations, Renewability and Recovery of the Issue
4-R Policies towards Sustainability Approach			
R_1: Reusing the Rejected Fish/ Shrimp Points/ Farms	**R_2: Recycling** the Land Resource in terms of Aquaculture and Agriculture	**R_3: Reducing** the Environmental, Ecological & Human Costs	**R_4: Recovering** the Problems & Issues derived from Shrimp Culture & **Researching** the Alternatives for Micro level Planning and Regional Development
Source: Author's Own Construction as per Field Survey, Data Analysis and Major Findings			

Table No.-16: Considerations for Environmental Impact Assessment of Shrimp Culture

Physical Parameters	Biological Parameters	Socio-cultural Parameters
• Bathymetric studies • Fluvio-coastal topography/ morphology and drainage • Salinity patterns • Surface hydrology • Description of water intake • Description of pumping station, delivery canal and effluent canal • Soil topography, morphology and quality • Water quality • Subsurface water quality • Description of flora and fauna communities	❖ Identification of landscape ecology and ecosystem network ❖ Identification of sensitive habitats and niches ❖ Identification of various ecosystem structure, function and productivity ❖ Identification of sensitivecommunities and species ❖ Identification of species ofcommercial importance ❖ Identification of endemic orthreatened species ❖ Introduction of non-endemicspecies ❖ Identification of protectedareas	➢ Identification of invest, return and productivity ➢ Identification and analysis of cost- benefit ➢ Identification of current land users ➢ Identification of populationcenters and makeup ➢ Income and employmentfigures ➢ Transportation and electricity ➢ Public services ➢ Areas of concern ➢ Identification of tools, techniques and technology in farming ➢ Identification of impact, mitigation and management measures ➢ Identification of plan, policy and strategy
Source: Author's Own Construction compiling Secondary Data [21] and Primary Data (Field Survey, Data Analysis and Major Findings -2018-2020)		

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VIII. CONCLUDING REMARKS

More ecological Researches on stabilization and protection, dynamics of fluvio-coastal character including other perspectives as well as documentation of flora and fauna which are tremendously affected by mainly shrimp cultivation in terms of aquaculture and also modern agriculture are urgently needed [4]. Yet, this research will expose opportunities for further research and investigation, and help decision makers to review what options exist for improving and humanizing coastal environment with its aquaculture facilities having uninterrupted ecology over Khejuri coastal segment [20]. Undoubtedly, shrimp cultivation will benefit the great majority of people, depends on government attitudes, proper planning and rational policies. There should be a clear-cut legislation, describing the categories of people who would eligible for shrimp cultivation. Depending on agro-ecosystem, the fluvio-coastal region should be categorized on the basis of salinity level to ensure proper uses of valuable land resources and avoid land use conflict. Considering the potentiality and feasibility of shrimp culture in different locations, traditional and semi-intensive culture systems should be introduced to increase the production. There should be legal and organizational efforts in maximizing the access to shrimp culture among land owners. Research organization, extension departments, college, universities and NGOs should come forward to provide training to shrimp farmers to improve their knowledge about farm management. The farmers should be instructed to maintain friendly ecosystem. Continuous efforts should be extended to organize the implementation of govt. policies regarding shrimp culture especially with a special focus on environmental and human cost of shrimp culture. [10] Finally, a balanced and sustainable method of exploitation can help humanizing the life of the local people with the blue-green practice of shrimp culture while maintaining ecological sense of balance of fluvio-costal habitats in the study area.

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